VOLUME 28 NUMBER 4

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NEW YORK MEETING, DECEMBER 4-7, 1906

THE AMERICAN SOCIETY OF MECHANICAL ENGINFERS

PROCEEDINGS

DECEMBER, 1906

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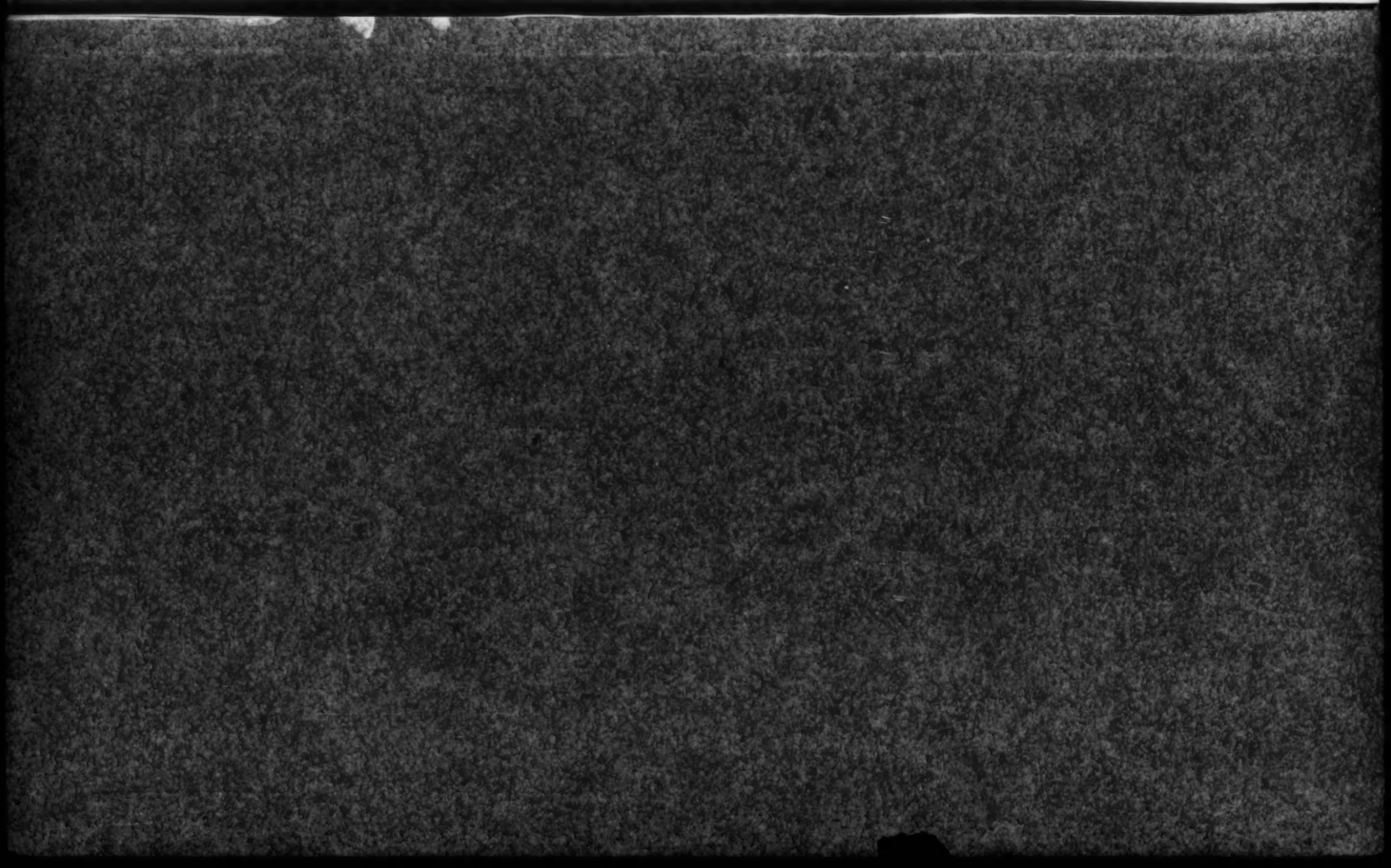

DECEMBER, 1906 VOL. 28. No. 4

THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

PROCEEDINGS

CONTAINING PAPERS
TO BE PRESENTED AT MONTHLY MEETINGS
OF THE SOCIETY

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PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 28 DECEMBER, 1906 NUMBER 4

BRING THIS COPY WITH YOU TO THE MEETING

The professional papers contained in this number of Proceedings are sent to you that you may prepare any discussion of them which you may wish to present. They are issued to the membership in confidence, and with the distinct understanding that they are not to be given to the press or to the public until after they have been presented at the meeting. All papers are subject to revision.

"The Society as a body is not responsible for the statements of facts or opinion advanced in papers or discussions." (C 55)

The price of Proceedings is $7.50 a year and $1.00 a copy.

THE ANNUAL MEETING

The Annual Meeting of the Society, which will be held in the Auditorium of the New York Edison Co., 44 West 27th Street, December 4–7, will be one of the most important meetings in the history of the Society. There has been great interest manifested in the papers which are to be presented, and it is expected that discussion mutually helpful to engineers will be contributed at the meeting. A large attendance of members and guests is anticipated, and the best accommodations and conveniences have been provided.

As before announced in these columns, a cordial invitation is extended to all persons who receive copies of Proceedings to be present at the sessions of the meeting.

ADDITIONAL TELEPHONE SERVICE

The Society takes pleasure in advising the membership that an additional telephone has been installed.

Our Telephone Numbers now are:

2123 Madison Square and 4655 Madison Square.

MONTHLY PUBLICATION OF CHANGES OF ADDRESS

Beginning with the January number and thereafter until further notice, changes of address received prior to the 15th of the month will be published in the Proceedings issued two weeks later. This will not apply to names received just prior to the publication of a Year Book or Pocket List.

The promptness and accuracy with which changes of address, etc., are now being made is evidently much appreciated by the membership. The system for recording and acting on requests of this sort is now very complete and will, it is believed, tend constantly toward better service.

The satisfactory handling of this kind of correspondence is one of the most difficult office problems in any national engineering society where the membership is very prone to move about and to change positions even where a change of residence is not involved.

No system, however, will be entirely satisfactory where six months changes are reported in the two weeks prior to the closing of the forms for an annual list. This necessarily means that assistants not familiar with the work must be called into service and clearly no time is afforded for the preparation of proper copy or for adequate proofreading.

It is with this idea in view that it has been decided to encourage more prompt reporting of changes of address by publishing them in Proceedings. This will give the entire membership advice in regard to professional and residential changes and also afford an opportunity to correct errors before they appear in the Year Book or Pocket List.

We invite the coöperation of the members in making this a feature of the Proceedings and in making it accomplish the principal purpose for which it is started.

ANNUAL REPORT OF THE COUNCIL

After some months of negotiations a contract for the sale of the House of the Society, at No. 12 West 31st Street, New York City, has been completed. The purchase price is $120,000, on which we pay $1000 commission. Possession is to be given to the new owner on March 1, 1907, and $5000 has been paid down to bind the sale.

When the house was bought in 1890 it was valued at $60,000, which price the Society paid, leaving $33,000 in a first mortgage still held by the former owners. The Society has had the use of the house for nearly sixteen years and now disposes of it for practically twice its original value, and considerably more than twice the cash advanced. The Society paid $27,000 in cash in 1890, and retires from the undertaking with $86,000.

Under the agreement between the Society and the holding corporation of the building of the United Engineering Societies, each of the Founder Societies is to pay within 20 years one-third ($180,000) of the price of the land ($540,000), and in doing so to make a payment of at least one-twentieth ($9000) of the total each year. Under this agreement the Society has had to pay this year the sum of $9000 which becomes an investment in the new building. In addition to a like sum next year the Society will have to pay its pro rata of the operating expenses of the United Engineering Societies. When the proceeds of the sale of the house, 12 West 31st Street are received they will be applied to paying off a part of this loan.

LAND AND BUILDING FUND SUBSCRIPTIONS

It has been decided to raise a sum of money approximating $100,000 by subscription to immediately pay off the obligations incurred by the Society through this change of quarters. The matter has been referred to the Executive Committee and will be laid by them before the entire membership at an early date.

It had been the hope of the Building Committee that it would be possible to hold the annual meeting of the Society in the new building, but it has been decided not to utilize the building until it should be in a more advanced state of completion.

The members of the Council were present by invitation at the laying of the corner stone of the building on May 8. The ceremonies were very simple and informal, the laying of the stone being performed by Mrs. Carnegie.

THE SIMPLIFICATION AND STANDARDIZATION OF THE SOCIETY'S METHODS

Through the kindness of the President, Mr. Fred. W. Taylor, the services of a skilled expert in the matter of book manufacture and office procedure have been secured in order that the methods now in use might be simplified and the existing systems where the best possible, be standardized and recorded for the use of those interested. The services of Mr. Morris L. Cooke, Junior member of the Society, were secured by the President and he has been actively engaged in these duties since February 1.

For the carrying out of recommendations, which would be the outcome of this study and recording process, a special Committee on Standardization and Systematization was appointed, to consist of the President, the Secretary, and Mr. Fred J. Miller. Messrs. Charles W. Baker and Henry H. Suplee were appointed a special committee of experts with the Standardization Committee on the special problems of publication, and Messrs. Meier and Stillman, present and preceding chairmen of the Finance Committee, have acted also, to consider suggestions concerning the financial details of the Society's office.

PROFESSOR'S HUTTON'S RESIGNATION

At a meeting of the Council held on January 30, 1906, the letter from the Secretary of the Society was presented.

NEW YORK, January 29, 1906.

To the Council, The American Society of Mechanical Engineers.

GENTLEMEN:

It may be known to some members of the Council that for several years I have had the thought in mind of resigning the Secretaryship of the Society on the completion of 25 years of service. I was first elected in March, 1883. My more recent thought has been that instead of waiting for a mere sentimental period to elapse, which would have meaning to myself alone, I might rather emphasize the more obvious culmination of my service to the Society by withdrawing at the time when the Society shall cross the threshold of its new home in the Engineering Building. It will then have been given to me to have wrought for the Society from the days of small beginnings, when I paid my own office rent and expenses, through the period of rented offices and of the ownership of the modest home in Thirty-first Street, and up to the opening of the days of larger opportunity in the splendid surroundings of the new enterprise.

It is wise, I am sure, that at the time of this external change, the Society should also make the internal change incident to securing as its Secretary one who will and can devote his entire time to the work and development of the Society.

It is well known to you that I have felt that I owe and must pay my first allegiance to the work of my professorship in Columbia University.

This being the case the Council should be advised far enough in advance so that the least embarrassment may be entailed by my withdrawal. I have thought it best to present this formal letter at the first meeting of the year, and to ask by it that proper action may be taken looking to the questions for the future which it raises. I ask that I may be relieved of the duties of the Secretaryship at the end of the current Society year, or at such other time thereafter as the Council may see fit to have this resignation take effect:

[Signed] F. R. HUTTON, *Secretary*.

The Council gave extended consideration to the problems which were presented by this letter. It was the final outcome of these considerations that the Society should recognize that in the work of the Secretary's office of an engineering society, there were two distinct sets of duties or functions. One of these is the conduct of the meetings and the public functions of the Society and the other the direction of the executive work. The Council also decided that it would be, in their opinion, of the greatest importance, that the person to be chosen Secretary of the Society, on the expiration of the term of the present incumbent, should, if possible, be chosen as early in the autumn as possible so that he might familiarize himself with the duties under the guidance of the retiring Secretary and take them up with the least jar to the routine of the Society's work.

THE CHOOSING OF THE NEW SECRETARY

It was decided that under the Constitution the most direct method of accomplishing this purpose, was to appoint the candidate for the position of Secretary, to a position of Assistant to the Secretary, until the expiration of the Secretary's term. It was referred to the Committee on Standardization to consider nominations asked for from the membership and make a recommendation to the Council. From the considerable list submitted, the Council selected five names, having in its opinion the strongest claim for eligibility; and, finally, from that list, by unanimous vote, elected Mr. Calvin W. Rice, a Member of the Society, Assistant to the Secretary, his services in this position to begin as soon as possible after he could arrange to discontinue his present relations, and to end with the election of the successor to the present Secretary, after the annual meeting in December, 1906.

APPOINTMENTS

The Council filled the vacancy created by the election of Mr. F. W.

Taylor, Vice-President of the Society, to the Presidency, by electing Mr. George H. Barrus of Boston to fill the office until the next annual election. Messrs. W. F. M. Goss, P. W. Gates, and George H. Barrus, have been appointed representatives of this Society on an Advisory Board to coöperate with the Fuel Testing Board of the U. S. Geological Survey; and Mr. John R. Freeman has been appointed a member of the Special Committee of the National Fire Protection Association to report on the San Francisco disaster.

The thanks of the Pennsylvania Railroad Company have been received from Mr. A. J. Cassatt, President, for the coöperation of the Society and the services of its members in connection with the conduct of the Locomotive Tests at the St. Louis Exposition in 1904.

The city of Indianapolis, Ind., has been selected as the place for the Spring Meeting of 1907.

Three reunions of the members of the Society, resident within convenient distances of New York City were held, on the last Tuesday of the months of January, February and March. The speakers for these evenings were Professor W. H. Bristol on "Thermo-Electric Pyrometers"; James M. Dodge on "Some Practical Results of the Introduction of a Modern System of Shop Management"; and Mr. C. J. H. Woodbury, on the "Mechanical Engineering of Telephone Systems."

The loss by death from the membership during the current year is reported as follows:

Thos. R. Almond	F. Grinnell	C. W. Phipps
P. H. Been	Ed. Thos. Hannan	A. J. Pitkin
W. B. Bogardus	I. V. Homes	Vernon H. Rood
James Brady	John C. Kafer	Louis Schutte
Chas. A. Bragg	J. R. F. Kelly	F. J. Shaw
Jas. A. Burden	F. P. Loscher	Geo. V. Sloat
Louis Cassier	A. C. McCallum	Chas. I. Spier
Geo. W. Catt	Max H. Miner	J. E. Stevens
James Dredge	Wm. Painter	M. P. Wood

The Council calls particular attention to the reports of the Standing Committees which follow. They will be found to contain reports and recommendations of special interest:

FINANCE COMMITTEE'S REPORT

The Finance Committee would report that by reason of the changes which have been made in certain important details of the Society's

office and printing work a very substantial saving has appeared to be possible for the coming year, as compared with the expenditures of the current year. The accounts of the Society have been audited as usual and a detailed report of the New York Audit Company is on file in the office. The following are condensed reports and cover the fiscal year October 1, 1905, to September 30, 1906:

CASH ACCOUNT

RECEIPTS

To cash on hand Oct. 1, 1905		$26.36
" current receipts	$52,194.67	
" Trust Fund subscriptions	340.00	
" first payment on property 12 W. 31st St.	5,000.00	
" savings banks	5,000.00	62,534.67
		$62,561 03

DISBURSEMENTS

By completion Vol. 26 (1904–5)	$4,715.52	
" current disbursements	39,133.91	
" reduction land loan	9,000.00	
" interest on land loan	6,000.00	
" cash on hand Sept. 30, 1906	3,711.60	$62,561.03

INCOME AND EXPENSE ACCOUNT

INCOME

Dues	$40,081.25	
Initiation fees	486.38	
Sales	2,779.51	
Rentals	1,230.50	$44,577.64

EXPENSE

Transactions, Vol. 27	$13,284.58	
Salaries	12,931.30	
Office	2,415.59	
Meetings	1,369.08	
Membership lists	2,253.52	
Circulars	2,079.47	
Membership development	764.34	
House	3,867.96	
Interest on mortgage	1,402.50	
Library	1,004.29	
Accounts written off	64.40	$41,436.93
Balance		3,140.71
		$44,577.64

BALANCE SHEET

October 1, 1906

ASSETS

Purchase contract, 31st Street property	$115,000.00	
Land and Building investment	23,462.80	
Furniture, book value	1,333.68	
Library, book value	12,987.07	
Plates	1,642.97	
Stock Transactions, etc	7,597.50	
Dues receivable	1,085.00	
Accounts receivable	1,810.68	
Advances	462.97	
Cash, trust funds	2,121.97	
Cash, available for current expenses	3,711.60	$171,80.24

LIABILITIES

Mortgage, 12 West 31st St	$33,000.00	
Reserved to complete Vol. 27	6,010.00	
Reserved accrued interest	350.00	
Advance payments	296.52	
Reserve Fund and Week's Legacy Fund	963.31	
Library Development Fund	1,509.94	
Trust Funds, M. E. L. A.	410.91	
Accounts payable	721.31	$43,262.61
Surplus		127,917.63
		$171,180.24

The above reports are made at such length as it is believed will be most convenient for the membership. The Committee will be glad at any time to provide members with more detailed information about any item which may not seem to be sufficiently covered in these necessarily brief summaries.

The following notes are offered as an aid to a fuller understanding of the financial reports and the accounting methods:

One per cent of the dues collected is appropriated to a Library Development Fund, the remaining 99 per cent is available for current expenses. Ten per cent of the initiation fees is available for current expenses, and the remaining 90 per cent disbursed on capital account only, as are life membership payments and the interest thereon.

Monies to be expended on capital account only as well as trust funds are kept in savings banks.

Ten per cent book value furniture and fixtures is written off annually. The Library is inventoried at an assessed value fixed by experts several years ago, plus

the value of acquisitions made since then; plates at the market value of the metal in them; Transactions and other stock at the estimated cost to reproduce.

Respectfully submitted,

E. D. MEIER, *Chairman*
MILTON P. HIGGINS
ANSON W. BURCHARD
ARTHUR M. WAITT
EDWARD F. SCHNUCK

MEMBERSHIP COMMITTEE'S REPORT

A circular letter was recently sent out to the membership, by the Secretary of the Society, under authority from the Council, asking for expressions of opinion as to the best means for improving the usefulness of the Society. Numerous replies urged that a more rigid scrutiny of the professional qualifications of the candidate for membership be made. The Membership Committee believes that the interpretation of the standard of professional requirements for membership in the Society, has never been more rigid than at present.

The Committee has met once a month during the past fiscal year beginning October 1, 1905, with average sessions of three hours each, and has studied the credentials of 400 applicants. One hundred and eighty of these have been passed to the Member's grade, of which number 41 were promotions from a lower grade. The total number passed to the Associate grade was 47, of which 14 were promotions from the Junior grade and 125 have been passed to the Junior grade.

The policy of the Committee has been to scan very critically the statement of the qualifications of each applicant for full membership, as well as those of his endorsers, and wherever a question of doubt existed as to qualification for the grade sought, action on the name has been deferred, and correspondence opened with a view of obtaining more detailed information, not only from his endorsers, but from the applicant himself, regarding his fitness and the character of his professional work.

It has been the distinct aim of the Committee to hold the standard of the Member's grade as high as it consistently could under the requirements of the Constitution; which makes demonstrated engineering ability a pre-requisite. If, in the opinion of the Committee, an applicant did not fully qualify as Member, he was promptly rated to the grade where he seemed to belong, and a courteous effort made through the Secretary to induce him to accept the Committee's rating. In the majority of cases this has been successful.

The Committee feels that there is often lack of consideration on the

part of the members of the Society in the matter of endorsing candidates for membership. There is a tendency to endorse a candidate because he is a friend or good fellow, rather than because of his experience and ability as an engineer.

It is not unusual for the Committee to rate an applicant to the Associate grade upon the statement of his personal service sheet and find that he has five endorsers who regard him as entitled to the Member's grade, but give little or no reason for their actions. This places the Committee in a difficult and embarrassing position, which might be easily avoided if the members in endorsing a candidate would exercise more care, and consider seriously whether the candidate to their personal knowledge, actually possesses the qualifications and experience requisite to make him a Member under the Constitution.

The Committee contemplates requesting the Council to authorize more stringent interpretation of those clauses of the Constitution relating to membership, and to adopt means for obtaining more exact knowledge of the professional qualifications of the applicants.

It is a pleasure to report that during the past year by far the larger share of the applicants have been men of a high order of engineering ability and wide experience. This same tendency to betterment in quality in noticeable among the Associates and Juniors, particularly the latter, where nearly all the applicants are technical college graduates.

Respectfully submitted,

IRA H. WOOLSON, *Chairman*
JESSE M. SMITH
E. I. H. HOWELLS
HENRY D. HIBBARD
FRANCIS BLOSSOM

REPORT OF THE HOUSE COMMITTEE

The House Committee would report as follows:

Appropriation	$4,650.00
Net Expense	3,963.80
Decrease Net Expense from Appropriation	$686.20

DETAIL OF EXPENSE

Accounts	Detail	Total.
House Account—Operation.		
Gas and Electric Light	$539.71	
Fuel	181.88	
Janitor's supplies	196.16	
Laundry	417.07	
Wages	1,740.00	
Insurance	124.04	
Incidentals	246.53	$3445.39

Repairs and Renewals		
House	$94.14	
Furniture	328.33	422.47
Additions		
Furniture	95.94	95.94
Total		$3,963.80

The income from use of house by members and others has been $1230.50, a slight improvement over last year.

The net cost of operating the house for the year exclusive of repairs and renewals, depreciations and mortgage interest was $2214.89, whereas the cost inclusive of mortgage interest was $3167.39, and the total expense including the above and repairs and renewals and depreciations has been $4450.48.

The Committee has to report with regret the loss through death of two interested and useful members, Mr. John C. Kafer and Mr. Thos. R. Almond.

The Committee would call the attention of the Council to the fact that upon the transfer of the Society at the end of 1906 or the first months of 1907, to the building of the United Engineering Societies on 39th Street, the duties prescribed in the Constitution and By-Laws for the House Committee will either disappear entirely, or if such Committee should be continued, the wording of the By-Law covering their duties should be modified to conform to the new Constitution. The Committee understand from representatives of the United Engineering Societies which will have control of the building on 39th Street, that the Society will no longer have direct control of matters respecting the house maintenance, the service of janitors, cleaning and the like, together with repairs and additions to furniture, which are not exclusively office requirements.

The Committee have approved the provisional estimate of the architects of the building for new office furniture, and has put into its budget for the year an item of $3000 to cover this expenditure which will be made through the architects and their contractors and not through the Committee directly.

The Committee in making its recommendations for the budget, have estimated that it would be called on to meet routine expenditure from October 1, to March 1, at which time at the latest, it must forego the present quarters of the Society on 31st Street.

The expenditure for additions, both house and furniture, passes through the hands of this Committee, but the net expense of same

is treated as an increase of assets and not as an expense through Income and Expense Account.

Respectfully Submitted,

GEORGE J. FORAN, *Chairman*
J. WALDO SMITH
W. H. DEANE
H. F. J. PORTER

REPORT OF THE COMMITTEE ON MEETINGS

We beg to report a successful meeting in the spring at Chattanooga, which was particularly well attended considering the situation, and the small number of members residing in the immediate vicinity.

An especial feature of the Committee's work is the preparation of a symposium of papers on engineering subjects, seeking to obtain a complete statement of the art on some one particular subject. The coming meeting in December is expected to be specially satisfactory and papers of extraordinary interest will be presented.

In coöperation with the Publication Committee the method of issuance of the Advance Papers in bound form was successfully tried at the Spring Meeting and has been improved further in the monthly "Proceedings," the first number of which was issued in September and will continue regularly for ten months of each year.

The suggestions sent in response to the circular letter of the Secretary, have been very carefully considered. We find that nearly ten per cent refer to the advisability of holding monthly meetings. It is therefore the intention of the Committee to provide these during the winter. It is further planned to devote special attention at these meetings to the development of the acquaintanceship of members.

Other suggestions refer to the issuance of the "Proceedings," provision for discussion in advance, abstracting papers and limiting the time of presentation, so that more time may be given for discussion.

The Committee is grateful to those who have taken such interest as to make suggestions and is alive to all the opportunities of its work.

Respectfully submitted,

CHARLES DAY
A. E. FORSTALL
CHAS. WHITING BAKER
CALVIN W RICE
GEO. R. HENDERSON

REPORT OF THE PUBLICATION COMMITTEE

The Publication Committee has held regular meetings during the

year, examining critically the papers and discussions presented at the various meetings, dividing this work among the members of the Committee according to their special lines of work. With the exception of one paper, with its discussions, all the papers were approved for publication. One paper was sent back to the Committee on Meetings with the suggestion that is be presented again before the Society with certain verifications and explanations.

The Committee has had before it for consideration the general conduct of the printing of the Society, and has caused careful specifications for the printing of the Transactions to be framed, in order that comparative bids might be obtained. Under these specifications new bids have been obtained, and the work awarded in such a manner as will insure the productions in a decidedly better style than heretofore, at a marked reduction in cost. The figures relating to these bids and awards will be referred to by the Finance Committee.

The Committee has prepared instructions to contributors to the Society's publications rendering it practicable for papers to be prepared in such a manner as will enable the publication to be made to the best advantage, and also to cause the subjects to be presented in the clearest manner possible, rendering the discussions more general and useful. The Committee has also in hand the preparation of a standard style sheet, giving instructions to the printers as well as our own employees, as to the general make-up of the various publications of the Society, including standard abbreviations, styles of type, reference authorities, etc., this work being still in hand.

The Committee has taken in hand the publication of the Year Book, and the Pocket List of members, with the result of a large economy in cost, and, it is believed, a material improvement in appearance.

Following out the plan of publishing the advance papers in quarterly installments, and thus securing the admission of the publication to the privileges of second-class mail matter, thereby effecting a large economy in postage, it has been deemed advisable to recommend the publication of the advance papers and other current information of the Society at more frequent intervals, in the form of Proceedings, this publication also replacing the numerous notices otherwise necessary, with their attendant cost of addressing and mailing, and placing in the hands of the members regular information concerning the work of the Society at a minimum cost, more promptly than otherwise possible. By the inclusion of notices of new books in the Proceedings, arrangements may be made with technical publishers by which the books can be secured for the library in exchange for listing in the Proceedings. The Year Book will probably also form one issue of the

Proceedings, and thus be issued in the most advantageous manner.

The Committee has in hand a complete system of the examination of papers submitted for publication, arranging for the papers to be distributed among its members in such a manner that each paper, with its discussions, may be critically read by at least two members of the Committee, selecting those members most familiar with the subjects, the records of the committee showing, for subsequent reference, by whom the papers and discussions were examined. It is believed that by this procedure the value of the Transactions will be increased, while at the same time irrelevant and useless matter will be eliminated.

Certain changes in methods have already been instituted which have already showed savings. Thus:

Total Appropriation	$11,870.00
Total Net Expense	10,521.56
Decrease Net Expense from Appropriation	$1,348.44

Respectfully submitted,

HENRY HARRISON SUPLEE, *Chairman*
C. J. H. WOODBURY
WALTER B. SNOW
HARRIS TABOR
D. S. JACOBUS

REPORT OF THE LIBRARY COMMITTEE

The Committee reports that during the current Society year the matter of the procedure to be followed by the Library and its Committee on the removal to the new quarters, has been much under consideration. By reason of practical difficulties in reaching definite conclusions the Committee has not been particularly active in the matter of book purchases, in order that duplicating might be avoided among the three libraries of the Founder Societies. Two hundred and sixty-seven volumes have been added during the year.

It has appeared generally desirable that the three libraries should be operated in such way as to give the greatest benefit to those who may desire hereafter to consult them, while at the same time conserving with every degree of completeness and care the individual title to the ownership of the books.

For this reason expenditure under the library control has been kept down to the salary of the Librarian $600, the binding of exchanges and library expense, $484.62.

During the spring the Secretary's office sent to all the membership a circular requesting, from those interested, suggestions concerning the work of the Society and for making the work more useful and available to the membership at large. The suggestions received cover the following points:

1 Provision for research by a technical man, at the request and expense of members who may desire to have such work done in the Library.

2 Provision for research, at the request and expense of members, as to those who make or do certain things, thus constituting a "bureau of information" on professional matters.

3 Provision for the circulation of the books of the Library among non-resident members.

4 A traveling library for the use of Junior members or for sections of the Society, to be retained for use for one or two months.

5 The indexing of books and periodicals by loose-leaf or other practical system, so that members may have the Library Index up to date.

6 The sending of notices to all members as soon as the new technical books are published, with comment as to their value.

7 That the Library should contain copies of all patents as issued.

8 That a collection of lantern-slides should be provided from which a "loan selection" might be made to all members, college professors and others for their lectures.

9 Improved service in the Library; improved lighting; a wider range of engineering subjects.

10 The securing of biographical data and historical data of important installations have also been mentioned.

These recommendations have been brought before the Council of the Society for consideration and action. The decision as to some of them will turn on the amount of expense involved and funds available, but the Committee desires to take this opportunity to thank the contributing members for these valuable suggestions.

The Library has been open every day between the hours of 10 a. m. and 10 p. m., except on Sundays and Thanksgiving, Christmas and New Year, and except one-half of the months of July and August when it was closed for cleaning and overhauling. An average of 10 persons per day made use of the Library during the busy season and about one-half of this summer during the vacation period of the summer.

The number of volumes in the Library, September 30, 1906, is as follows:

Books	9366
Pamphlets	3150
Maps	33

Respectfully submitted,

HENRY R. TOWNE, *Chairman*
W. D. FORBES
FREDK. M. WHYTE
GEO. F. SWAIN
AMBROSE SWASEY

PROGRAM OF THE ANNUAL MEETING

The Annual Meeting will be held in the auditorium of the New York Edison Company, 44 West Twenty-seventh Street, where the official headquarters will be opened Tuesday, December 4, at noon, and maintained throughout the meeting. The headquarters and general arrangements will be in charge of Mr. Francis W. Hoadley, (Badge No. 5) Assistant to the Secretary.

REGISTRATION

Each member and guest will be given at the registration desk a blank form (see form below) in triplicate. In filling this out, use a hard pencil furnished at the desk. Please write so as to make the name and address perfectly legible. Register early that your name may appear on the first edition of the member's Register. Through this means, members and guests can be located either by name or number.

REGISTRATION FORM

No_____

NAME _____

Grade or Guest of _____

Home Address _____

_____

Convention Address _____

_____

Business Affiliation _____

_____ **Date** _____

Numerical and alphabetical files of these slips can be consulted at all times at the Registration Desk.

ROSTER OF THE MEETING

(For details see succeeding pages)

Tuesday, Dec. 4.	Noon.	Headquarters will open.
	8:30 P. M.	President's Address and Social Reunion.
Wednesday, Dec. 5.	9.30 A. M.	Annual Meeting and Professional Session.
	2:00 P. M.	Professional Session.
	Wednesday Evening unassigned.	
Thursday, Dec. 6	9:30 A. M.	Professional Session.
	2.00 P. M.	Inspection Trip to Port Morris Power House.
	9:00 P. M.	Reception at Sherrys.
Friday, Dec. 7	9:30 A. M.	Professional Session.

MISCELLANEOUS NOTES

Two editions of the printed Members' Register will be issued and will be distributed at the morning session on Wednesday and at the reception on Thursday. The names registered up to eight o'clock on Tuesday evening will be included in the first edition. The second edition will close at noon on Thursday.

The officers of the Society and officials of the meeting will be designated by the following badge numbers.

No. 1 Mr. Fred W. Taylor, *President.*

No. 2 Hon. Wm. H. Wiley, *Treasurer.*

No. 3 Prof. Frederick R. Hutton, *Secretary* and nominee for President.

No. 4 Mr. Calvin R. Rice, *Assistant to the Secretary.*

No. 5 Mr. Francis W. Hoadley, *Assistant to the Secretary.*

No. 6 Mr. Charles A. Morrison, *Official Stenographer.*

Applications for membership should be made on a standard form which can be procured at the Registration Desk. The application having been filled out, it should be sent to the Secretary's office. The Secretary will thereupon communicate with the references of the applicants and will submit to the Membership Committee and Council both applications and replies. Meetings occur in December and in the late Spring, at which time the election of members is officially announced.

OPENING SESSION

Tuesday Evening, December 4, 8.30 o'clock

President's Address "The Art of Cutting Metals." Mr. Fred W. Taylor, Philadelphia, Pa.,

SOCIAL REUNION

The reading of the President's Address will be followed by a social gathering, during which refreshments will be served. Ladies will be especially welcome at this session.

SECOND SESSION

Wednesday morning, December 5, at 9.30 o'clock

Annual business meeting. The annual reports of the Council, Tellers, Standing and Special Committees will be presented. New business can be presented at this session or at the Friday morning session.

Report of the Committee on Standard Proportions for Machine Screws.

Discussion on President's Address: "The Art of Cutting Metals."

In order not to curtail unduly the time to be devoted to the Social Reunion at the Opening Session, it has been decided to postpone the discussion of the President's Address until the Second Session, when ample time will be afforded for this purpose.

This session will adjourn punctually at 1 o'clock to the floor below, where buffet luncheon will be served.

THIRD SESSION

Wednesday afternoon, December 5, at 2 o'clock

POWER PLANT SYMPOSIUM

"The Evolution of Gas Power," by Mr. F. E. Junge, of Berlin, Germany.

"Producer Gas Power Plant," by Mr. J. R. Bibbins, of Pittsburg, Pa.

"Steam Turbine Characteristics," by Mr. Hans Holzwarth, of Hamilton, Ohio.

"A High Duty Air Compressor," by Prof. O. P. Hood, of Houghton, Mich.

"Design of an Improved Boiler Setting," by Mr. A. Bement, of Chicago, Ill.

"The Steam Plant of the White Motor Car," by Prof. R. C. Carpenter, of Ithaca, N. Y.

After the afternoon Session the members are invited to inspect the Engineering Building located at 29 West 39th Street. This may

be reached by walking up Fifth Avenue or by Sixth Avenue surface cars.

Wednesday evening unassigned

FOURTH SESSION

Thursday morning, December 6, at 9.30 o'clock

"Saw-Tooth Roof Construction," by Mr. F. S. Hinds, of Boston, Mass.

"Ferroinclave Roof Construction," by Mr. A. E. Brown, of Cleveland, O.

"Saw-Tooth Roofs for Factories," by Mr. K. C. Richmond, of Providence, R. I.

"Weights and Measures," by Mr. Henry R. Towne, of New York, N. Y.

"Mechanical Engineering Index" by Prof. W. W. Bird, and Prof. A. L. Smith, Worcester, Mass.

EXCURSION

Thursday afternoon, December 6, at 2 o'clock

EXCURSION TO PORT MORRIS POWER STATION.

Through the courtesy of Mr. W. J. Wilgus, Vice-President New York Central & Hudson River Railroad Company, an invitation is extended to the members to visit the power station of that road at Port Morris.

A special train will leave the Grand Central Station at 2.15 p. m., gates open at 2 p. m.. and it is expected that the party will reach the city on its return about 4:30 p. m.

TICKETS REQUIRED

Tickets for transportation New York to Port Morris and return must be obtained at the Registration Desk in Convention Headquarters, and as the excursion will be limited in numbers to the capacity of the ten car train provided, those desiring tickets should obtain them during the early days of the meeting.

A guide will be assigned to each car, and the members are invited to stay by that guide throughout the trip.

DESCRIPTIVE BOOKLET

An illustrated booklet, describing the power station and giving historical data, etc., regarding the electrification of the New York Central & Hudson River Railroad can be obtained at the Registration Desk during the meeting.

RECEPTION

Thursday evening, December 6, at 9 o'clock

To be held at Sherry's, Forty-fourth Street and Fifth Avenue, entrance on Forty-fourth Street.

The President and President-elect will receive the members and guests. Dancing will follow the reception and will continue throughout the evening. Supper will be served from 10 until 12 o'clock. In order to avoid crowding, it is suggested that those who must go out of town be served as soon after ten o'clock as possible and those who live in town delay their luncheon, that all may be served with convenience. This is the only distinctively social feature of the meeting and the attendance of the visiting ladies is especially desired. It is urged that no one shall remain away because the exigencies of travel have made evening dress inconvenient. Cards of admission will be required from all members and guests. These can be procured at the Registration Desk.

CLOSING SESSION

Friday morning, December 7, at 10 o'clock

"Ventilation of Boston Subway," by Mr. H. A. Carson, of Boston, Mass.

"Flow of Liquids in Venturi Tubes," by Mr. E. P. Coleman, of Buffalo, N. Y.

"Tests of an Elevator Plant," by Mr. A. J. Herschmann, of New York, N. Y.

"Test of a Rotary Pump," by Prof. W. B. Gregory, of New Orleans, La.

"Improved Transmission Dynamometer," by Mr. W. F. Durand, of Stanford University, Cal.

"A Plan to Provide Skilled Workmen," by Mr. M. W. Alexander, of Lynn, Mass.

INVITATIONS

The New York Electric Music Company, invite the members of the Society to visit the plant of the Cahill Telharmonic System at 1414 Broadway, Corner of 39th Street. The music is heard through the telephone. Recitals are in progress daily from 3 to 5 p. m.

The Automobile Show at the Grand Central Palace, 43d Street and Lexington Avenue will be open December 1–8. Complimentary tickets may be obtained at the Registration Desk through the courtesy of one of our members.

The New York Edison Company invite the members of the Society to visit the two power stations, Waterside No. 1 and No. 2 where they may see in operation steam turbines of the largest size of the General Electric Curtis and Westinghouse-Parsons type. The member's badge will be recognized as a means of introduction.

JAMES ABERCROMBIE BURDEN

MR. BURDEN was born in Troy, N. Y., January 6, 1833. In his early youth he gave evidence of his mechanical and engineering genius. He received his education in Sheffield Scientific School, Yale, and the Rensselaer Polytechnic Institute. He went into the works to learn the iron business, and his wonderful executive ability and organizing genius, which later won for him the rank of Captain of Industry, became apparent.

He was an inventor of several devices for iron manufacture, and held 18 patents of his inventions.

Mr. Burden was interested in many charities, and as a man and citizen he took an active part in political and philanthropic affairs. He could never be induced to accept a public office, but was Presidential Elector for two Presidents. In addition to his ownership of the great iron manufactory he was a member of the Stanton Steamer Company. He gave financial aid in the building of churches and hospitals, and was greatly interested in the Benevolent Association, which bears his name.

He was a member of the American Society of Civil Engineers, The American Institute of Mining Engineers, as well as of this Society. He was a member of many clubs and leagues in America, and also of several engineering and scientific societies in England. He was the first President of the Engineers' Club, and was a member of the New York Chamber of Commerce and American Museum of Natural History. At the time of his death, which occurred September 24, 1906, in Troy, N. Y., he was President of the Burden Iron Company.

CHARLES WALTER PHIPPS

MR. PHIPPS was born in Worcester, England, on January 5th, 1859, and came to America when a youth, and soon became associated with the Brush Engineering Company of Cleveland, Ohio.

In later years he was identified with important electrical developments of the time, among which were the original installations of the arc light in England, China, and Japan. In the latter case it was the first electrical apparatus of any kind installed in that country.

After several years absence in the far East, Mr. Phipps returned to America and became Manager of the Brush Company; he was later associated with the Adams-Bagnall Electrical Company, manufacturers of arc lamps. In 1891 he was made Manager of British-Thompson, Houston Co. at Rugby, Eng., which position he held until his death, August 31, 1906.

Mr. Phipps became a member of the Society in 1892.

ACCESSIONS TO THE LIBRARY

THE DESIGN AND CONSTRUCTION OF CAMS. By C. F. Smith, Frederick A. Halsey, and others. *Hill Publishing Co., N. Y., 1906.*

THE COST OF LOCOMOTIVE OPERATION. By George R. Henderson, New York, *1906. Railroad Gazette Pub. Co.*

INTERNAL ENERGY. By John V. Booraem, N. Y., 1906. *McGaw Pub. Co.*

THE SAN FRANCISCO EARTHQUAKE AND FIRE. By A. L. A. Himmelwright. *The Roebling Construction Co., N. Y., 1906.*

ENGINEERING STANDARDS COMMITTEE. Reports 24, 18 and 31. *London, 1906.*

BUREAU OF LABOR OF CONNECTICUT. *Annual Report, 1905.*

NATIONAL FIRE PROTECTION ASSOCIATION—*Quarterly Bulletin of the Committee on Special Hazards and Fire Records, October, 1906.*

NATIONAL BATTERY COMPANY, BULLETINS, 1–6. *1905–1906. Buffalo, N. Y.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of the Proceedings, Vol. 164, 1906. *London, England.*

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA—*Index to Proceedings, Vols, 1–20. 1880–1904.*

CHEMICAL METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA. *Journal, Aug., 1906.* Supplement, Report of Sub-Committee on the Standardization of Battery Screening.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 20th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

01 Wanted by an engine building concern in Ohio, a man competent to take charge of the shops as Superintendent of Construction. Familiarity with the manufacture of steam and gas engines only is required.

02 Capable man to act as Works Manager for a large corporation employing at present about 2300 hands. The man for the position must have good executive ability, and be able to act with a great deal of tact. Position particularly desirable for the right man. Location, Massachusetts.

03 Wanted, a mechanical engineer to take charge of a plant of a large manufacturing establishment. Must have had experience. He will not only have charge of the steam plant but also the electrical equipment and in a general way the entire machinery of an establishment employing three thousand men. Salary adequate to the man and the position. Location, Connecticut.

04 Young man for drafting work and to work himself up into the Engineering Department of New Jersey concern, in electrical and mechanical lines.

05 Man with previous experience in the building of high speed engines, if possible wite some experience in the design of four-valve engines. Whose education and experience has been such as to make him competent to look after a large part of the designing of high speed single-valve and four-valve engines. Will have further duties of advisory engineer in engineering matters that come up for adjustment. Well versed in modern methods of shop practice.

06 Designer of machinery in connection with manufacture of iron tools. Must be able to work up designs from rough sketch. Massachusetts concern.

07 An industrial establishment within 50 miles of New York City desires a general superintendent, who by experience and temperament is qualified to develop organization, to provide discipline, to give best care of men, to secure most improved methods of manufacture, to intelligently reduce cost. Salary adequate.

08 Civil Service Commission (Room 875) City Hall, Philadelphia, Pa. Chief of Bureau of Water; examination to be held December 4, 1906, 9 A. M. Salary, $6,000. Executive ability, experience, personal fitness and character, capacity for organization as shown by previous record and by responsibilities carried, will be essential. Examination will cover questions upon civil and mechanical engineering. Applicants from a distance may secure application blanks as late as Monday morning, December 3d at office of Civil Service Commission, to be filed before 3 P. M. same day. Examination both written and oral.

MEN AVAILABLE

1 British mechanical electrical engineer of 16 years experience in design, construction and operation of steam, electrical, compressed air and hydraulic plants, traction work, reconstruction of cement and other industrial works, specification, inspection and installation of general machinery, desires engagement by American organization. Has been for past two years in New York on behalf of large contracting firm with whom he has worked for the last 6 years.

2 Member, 20 years experience with steam power equipment and accessories, principally selling. Particular executive capacity for management of construction, operating or sales department of engineering works and for economical and systematic distribution of materials and labor. Wide acquaintance in United States, Canada and Europe. Willing to go abroad.

3 Mechanical Engineer, 35 years of age, at present engaged in designing automatic machinery for a well known paper mill in Massachusetts, desires change. A1 tool designer, machine tools, and interchangeable manufacturer. Executive ability, practical technical experience. First-class references from past and present employers.

4 Special work outside office hours, evenings, desired, by Junior member near New York. Technical graduate, ten years experience layout of plants, design, manufacture, and operation of steam engineering apparatus.

5 Member, with 12 years of experience on several of the principal railroads of the United States wants position as master mechanic for a railroad. Satisfactory references. Location, immaterial.

6 Mechanical engineer, 27 years old, desires position in vicinity of New York City. Three years experience in general factory engineering, drafting, testing, mill construction, etc. Desires position as assistant or understudy in some business concern.

7 Technical graduate, 35 years of age with six years general shop and drafting room experience and ten years of teaching experience, would like engagement in mechanical department of some college or university of the middle west. Best of references.

8 Member with several years experience in designing special metal working machinery and tools for manufacturing purposes, offers his services along with (or without) new line of improved power presses. Location, central or western.

9 Member with expert experience in factory cost accounting and in the installation of labor-saving appliances in cost department work, would like engagement with concern having large number of employees Competent to devise and install practical systems of minute accuracy that can be cheaply and successfully operated with inexperienced clerical help Invites correspondence with firms that seek exact information as to cost of output.

10 Mechanical engineer, technical graduate with 12 years practicalex perience in shop and field. For several years and at present, chief engineer in large manufacturing plant in charge of construction, maintenance and power equipment Qualified for responsible charge of construction or operation.

11 Graduate of Columbia University. Desires to work into the "business end" of engineering. Experience in operation of tannery plants, installations, and study of economy of operation, including tests of boilers and furnaces, steam and gas engines; efficiency tests for types of furnace in use of burning tan bark, waste fuels, etc., including design and operation of automatic stoker furnace. Executive experience in handling and training of men.

12 Junior member, Michigan graduate, 6 years experience Now chief draftsman manufacturing company, desires position with commercial vehicle company as mechanical engineer, assistant manager or assistant superintendent Three years exclusive experience on sight-seeing cars, trucks up to six tons, railroad cars up to thirty, passengers, gasoline locomotives. Can handle office, drafting room. correspondence

OFFICERS AND COUNCIL

1905—1906

PRESIDENT

FRED W. TAYLOR ..... Philadelphia, Pa.

VICE-PRESIDENTS

S. M. VAUCLAIN ..... Philadelphia, Pa.
H. H. WESTINGHOUSE ..... Pittsburg, Pa.
GEORGE H. BARRUS ..... Boston, Mass.

Terms expire at Annual Meeting of 1906

WALTER M. MCFARLAND ..... Pittsburg, Pa.
EDWARD N. TRUMP ..... Syracuse, N. Y.
ROBERT C. MCKINNEY ..... New York, N. Y.

Terms expire at Annual Meeting of 1907

TREASURER

WM. H. WILEY ..... 43–45 East 19th St. ..... New York, N. Y.

SECRETARY

PROF. F. R. HUTTON ..... 12 West 31st St., New York, N. Y.

MANAGERS

GEORGE I. ROCKWOOD ..... Worcester, Mass.
JOHN W. LIEB, JR ..... New York, N. Y.
ASA M. MATTICE ..... New York, N. Y.

Terms expire at Annual Meeting of 1906

GEO. M. BRILL ..... Chicago, Ill.
FRED J. MILLER ..... New York, N. Y.
RICHARD H. RICE ..... Lynn, Mass.

Terms expire at Annual Meeting of 1907

WALTER LAIDLAW ..... Cincinnati, O
FRANK G. TALLMAN ..... Wilmington, Del.
FREDERICK M. PRESCOTT ..... Milwaukee, Wis.

Terms expire at Annual Meeting of 1908

CHAIRMAN OF FINANCE COMMITTEE

E. D. MEIER

PAST PRESIDENTS

JAMES M. DODGE
JOHN R. FREEMAN
EDWIN REYNOLDS
AMBROSE SWASEY
S. T. WELLMAN

THE TESTING OF INFLAMMABLE GASES

By C. E. SARGENT, CHICAGO, ILL.
Member of the Society

1 With the increasing demand for internal combustion engines, the great activity in by-product and producer plants, and the vigorous growth of gas industries, the testing of gases for their calorific value and foreign ingredients is one of the duties of the engineer, and a simple, quick, and efficient method of making such determinations greatly facilitates his work.

2 In making efficiency tests of gas engines and in determining the solid matter, moisture, and calorific value of gases, methods have been used and apparatus designed by the writer which give uniform and rational results heretofore obtained through more tedious operations.

3 In order to determine the heating value of a gas it is necessary to utilize all the heat of combustion in doing tangible work which can be measured without error or loss. The heat of combustion of a measured quantity of gas is used to raise the temperature of water; and the quantity of water, the rise in temperature, and the volume of gas are the three factors necessary to get its calorific value.

4 In order to prevent a possible error of radiation, the temperature of the gas, surrounding air, inlet water, and exhaust products, should be practically the same; then if the loss of heat by radiation from the water whose temperature is rising is obviated, reasonable results are possible.

5 In the apparatus used by the writer, the inlet water, the temperature of which should be practically that of the surrounding air, envelops the whole calorimeter, thereby carrying in the heat which it might absorb from the water whose temperature is rising.

6 Fig. 1 shows a section of a calorimeter in which the inlet water, having a constant head at the cistern E, the temperature of which is taken at C, envelops the whole instrument and passes through

To be presented at the January, 1907 (New York) meeting of The American Society of Mechanical Engineers, and to form part of Volume 28 of the Transactions.

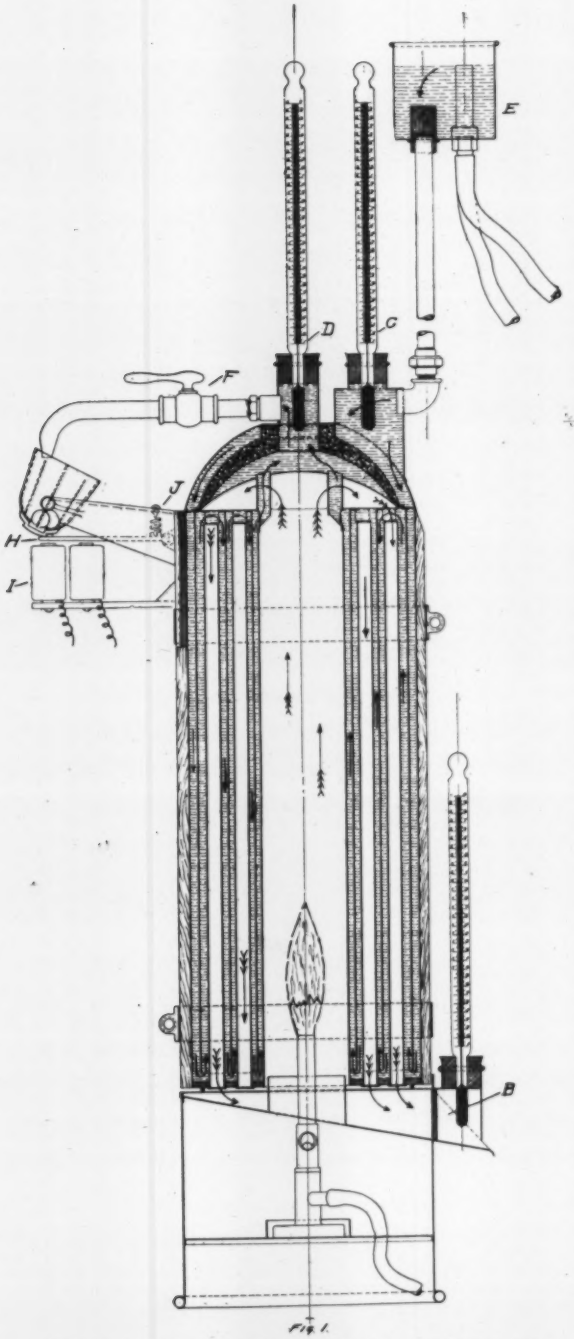

FIG. 1 DETAIL OF SARGENT GAS CALORIMETER

in the direction of the arrows ⇛→, and the rise in temperature is taken by the thermometer at *D* before any heat is lost by radiation to the air. The combustion of gas takes place in the central flue and the products of combustion pass to the top and down the annular chambers in the direction of the arrows ⇛→, reaching the temperature of the water before passing out at *B*, where a damper regulates the velocity and the thermometer gives the temperature of the exhaust products.

7 The calorimeter should be operated in a closed room free from air currents which disturb the equilibrium and vitiate results. Even with the most perfect conditions, errors from observation or conversion are possible. When B.t.u. are desired, as is the case in most English speaking countries, and Centigrade thermometers are used, mistakes are sometimes made in transformation. As a degree Fahrenheit is $\frac{5}{9}$ of a degree Centigrade, when both are divided into tenths, the Fahrenheit thermometer will give nearly twice as close a reading as the Centigrade instrument.

8 When the outlet water is measured in graduated beakers, it must be changed from cu.cm. to pounds. The varying meniscus, the possibility of the beakers being out of level, and the temperature of the water are elements of error possible when the outlet water is measured. By weighing the discharged water and using Fahrenheit thermometers, no transformation from cu. cm. to grams, from Centigrade to Fahrenheit, or from calories to B.t.u. are necessary, Readings are direct in B.t.u. and errors of transformation and the mysteries of metric measurements are entirely eliminated.

9 One of the greatest errors in determining the calorific value of a gas arises when the operator attempts to switch the outlet water from one receptacle to another after a certain quantity of gas has been burned. To eliminate this "personal error" the automatic dumping bucket, shown in Figs. 1 and 2, was designed. This bucket is held in position by the keeper *H* and spring *J*. The weight of the water on the full side tends to oscillate the bucket so that the water will flow into the empty side and through another outlet to the empty receptacle. When the test meter needle passes the zero point (behind the binding post, Fig. 2) an electrical circuit is completed, which, passing through the solenoid, Fig. 1, draws down the keeper *H* and allows the outlet water to automatically change from the full to the empty pail, Fig. 2.

10 With such a device the personal error is not only eliminated but much of the work of the operator is done automatically, thereby allowing him more time for observing the temperatures and weighing the water delivered. By switching the water for every tenth of a cubic

foot of gas burned, observations are taken about every four minutes and the calorific value can be determined for the preceding test before the meter needle completes its next rotation. In this way a test may continue without intermission as long as the engine is in operation, or the producer is furnishing gas.

11 Since producer gas with a varying feed and output and natural gases coming from different wells, are often mixed with illuminating or water gas to keep up the pressure where the demand in large cities during zero weather exceeds the supply, the illuminating gases

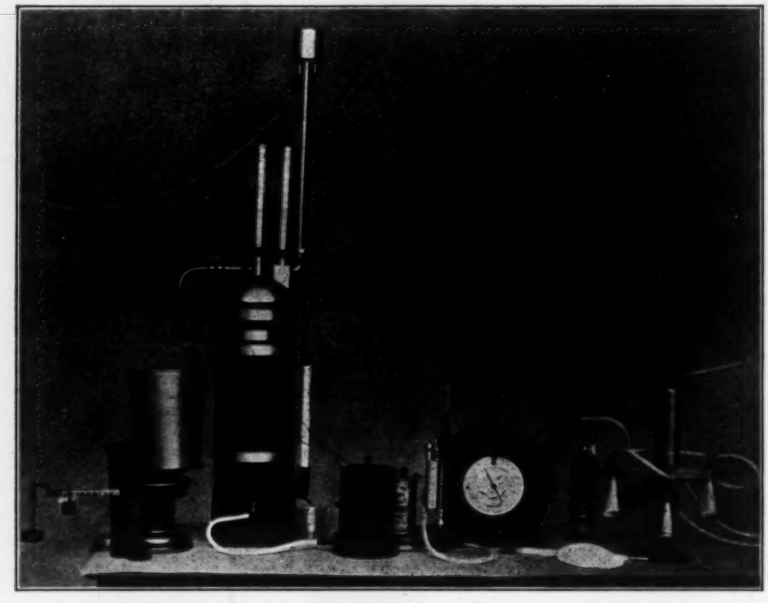

FIG. 2 EXTERIOR VIEW SARGENT GAS CALORIMETER

may vary in calorific value during the conditions of manufacture. Therefore, short runs but continuous determinations are necessary for satisfactory and rational results.

12 If the thermal efficiency of an engine is desired, the calorific value of the meter gas only is necessary, but for the sake of comparison, the B.t.u. are usually given in cubic feet of standard gas. The book of tables compiled by Professor McFarland, member of the Society, enables the operator to change meter gas to standard gas, merely by knowing the temperature, pressure, and barometer readings. With Fahrenheit thermometers, scales weighing to hundredths of a pound,

tables reducing meter gas to standard gas, and automatic devices not only to do a great deal of the operator's work but to eliminate the error which necessarily arises under hand manipulation, the determination of the heat units of any gas by the calorimeter becomes a simple matter.

13 In testing producer gas below atmospheric pressure it is necessary to raise the pressure with a water ejector, but as this may add

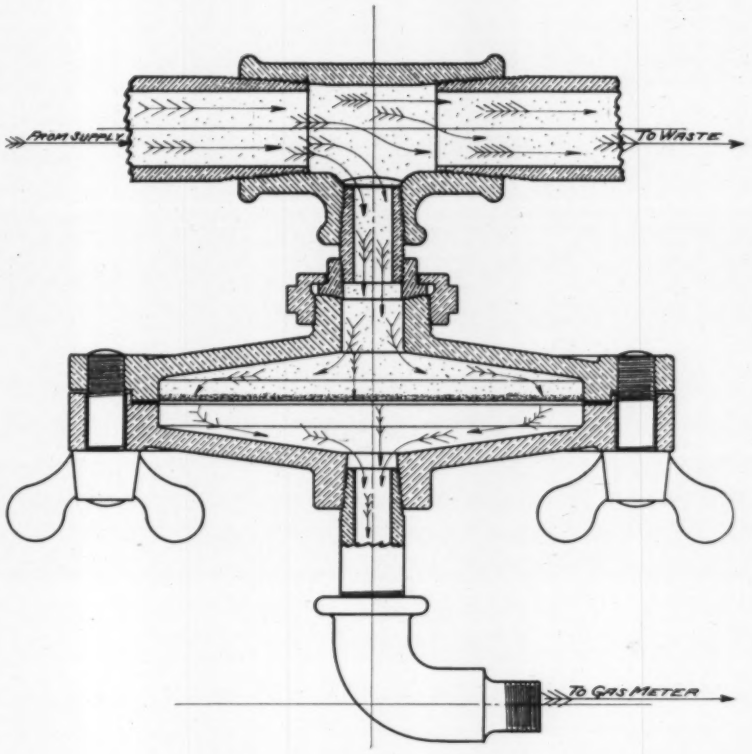

FIG. 3 DETAIL OF FLOOR OF GAS IN SARGENT DUST DETERMINATOR

more or less water to the gas, the pressure is preferably raised with an electric or hydraulic driven centrifugal fan, as no moisture is added to the gas by this method.

14 When testing gas has been washed and dried to determine the efficiency of the drier, the gas is passed through a condenser to reduce its temperature, or through calcium chlorid bottles to absorb the moisture, or through both, as the conditions demand. By weighing

the bottles and the calcium before and after and knowing the cubic feet of gas, the percentage of moisture is readily obtained.

15 When the efficiency of the gas washers is required, *i.e.*, the grains of dust per cubic foot in the washed gas, at the same time the calorific value is determined, the gas is passed through a filter paper, the holder of which is shown in section in Fig. 3, which retains every

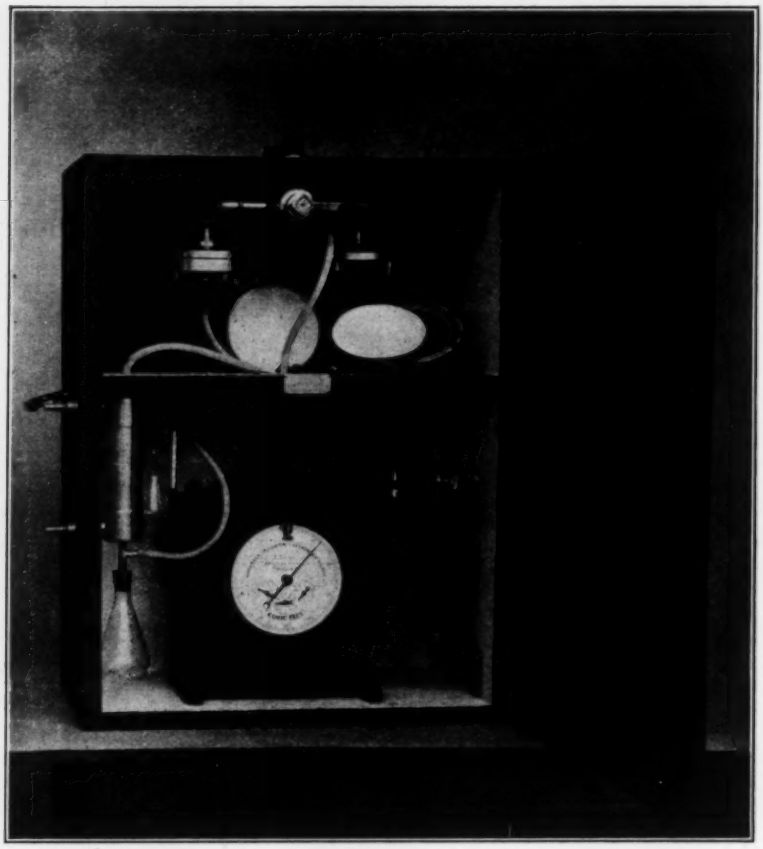

FIG. 4 EXTERIOR VIEW SARGENT DUST DETERMINATOR

particle of dust, as is proved by letting the gas pass through two filter papers in series, the second of which remains white and does not increase in weight.

16 When gas is tested for dust and moisture only, a self-contained outfit, Fig. 4, provides for continuous determinations. The gas passes through a filter, condenser, calcium chlorid bottles, and test meter,

and while the accumulations of dust on one filter paper are being weighed, gas is passing through the other. In this way a continuous record of the dust in blast furnace gas is determined and the efficiencies of the working apparatus maintained.

17 The calorimeter complete, as used by the author, consists (Fig. 2) of a test meter, which reads in cubic feet—one revolution of the pointer of which measures 1/10 of a cubic foot—gas thermometer, pressure gage, one pressure regulator with micrometer adjustment, one Bunsen burner, and one calorimeter proper with inlet, outlet, and exhaust products, thermometers graduated in tenth of degrees Fahrenheit, automatic dumping bucket, dry batteries, balanced copper pails, and decimal platform scales. When gas is tested for solid matter at the same time its calorific value is determined, the tar, moisture, and dust extractors as shown on the right are used.

18 As the products of combustion are saturated, the gas and air should be saturated if the net amount of hydrogen in the gas is desired.

19 In determining the calorific value of metered gas, no corrections for pressure and temperature are made and the results would be recorded as follows:

LOG

DATE, AUG. 14, 1906. KIND OF GAS, NATURAL, FOR K. C., B. & N. CO. AT K. C., MO.

TIM	TEMPERATURE °F						CU. FT.	LBS.	B T. U.
P.M.	H_2O-IN	H_2O-OUT	DIF.	GAS	AIR	EXHAUST	GAS	WATER	
1:30	62.5	72.	9.5	62	62	62.1	.1	8.91	846.45
1:34	62.5	72.	9.5	62	62	62.	.1	8.93	848.35
1:38	62.6	72.1	9.5	62	62	62.1	.1	8.90	845.5
Average	62.533	72.033	9.5	62	62	62.06	.1	8.913	846.76

20 In this case 1/10 of a cubic foot of gas is burned every four minutes and the B.t.u. are determined for every tenth of a foot consumed. In like manner the log may be continued indefinitely or as long as an engine test may last.

21 As the temperature of the gas, air, and exhaust products should be practically constant and as these temperatures are not used in the calculations, a record for each reading is seldom taken. Often these temperatures are noted only under remarks or at the beginning of the log, which simplifies the work and allows room for reducing the metered gas to standard gas during the observations. When such results are desired the log would be as follows:

DATE.....GAS.....FOR.....AT.....

	TEMPERATURE °F.				PRESSURES	
	ROOM	GAS	EXHAUST		BAROMETER	GAS
START	60	60	61		28.854	.5
FINISH	61	60	60		28.854	.5

TIME	H_2O-IN	H_2O-OUT	DIF	LBS. WATER	CU. FT. GAS		B. T. U.	
					METERED	STANDARD	METERED	STANDARD
3.25	60.5	69.8	9.3	9.5	.1	.09704	883.5	857.
3.28	60.5	69.9	9.4	9.5	.1	.09704	893.5	866.
3.32	60.5	69.9	9.4	9.48	.1	.09704	891.1	864.
Average	60.5	69.86	9.37	9.49	.1	.09704	889.0	862.3

22 From the barometer readings, 28.854 in above log we add 0.037, the pressure of $\frac{1}{2}''$ water in mercury, making the absolute pressure of the gas, 28.9 and, from the tables above referred to for gas of 30″ Mg. and 62 degrees Fahr., we find the constant to be 0.9704, which multiplied by the B.t.u. of metered gas gives the B.t.u. of standard gas.

23 The B.t.u. obtained are the total or high value of the gas. As the exhaust products of a gas engine are hotter than boiling water and the products of combustion of the hydrogen and oxygen are in the form of steam, the latent heat of the steam in the products of combustion must be subtracted from the total B.t.u. to get the low or available value.

24 As the latent heat of steam is 966.6 B.t.u. per pound and as the condensed water which is cooled down to the temperature of the exhaust products absorbs this additional amount of heat, the available heat in the gas equals the difference between the high value and the B.t.u. represented by the pounds of steam condensed times the latent heat of steam plus the difference between 212° and the temperature of the exhaust products.

25 As soon as the dripping of the water coming out with the products of combustion is uniform, the test for the low value can be started and run while the high value is being obtained. From one to three feet of gas are burned before condensed water is weighed and the difference between the high and low value is ascertained.

26 If during these determinations of the heating value of a gas showing an average of 960 B.t.u. per cubic foot, three cubic feet of gas are burned and there is collected 0.15 pound of water, and the temperature of the exhaust gases is 60 degrees Fahr., the hydrogen products would be $(9666.6 + (212 - 60)\ 152 \times .15 = 55.9$ B.t.u., which subtracted from the high value $(960 - 55.9)$ gives 904.1 B.t.u., the available heat in the gas when used in an engine whose exhaust is hotter than 212 degrees Fahr.

27 The percentage of dust per cubic foot is determined in like

manner. The filter paper is dried and weighed and after several feet of gas have passed through, it is again dried and weighed and the grains per cubic foot are determined.

28 In conclusion, the author finds that the analysis of gases for their B.t.u., dust, and moisture is greatly facilitated,

a By enveloping the water whose temperature is rising with the inlet water to prevent radiation.

b By using Fahrenheit thermometers graduated in tenth degrees.

c By making frequent but continuous determinations when testing gases whose calorific value varies.

d By having the water automatically switched from one receptacle to another when a tenth of a foot of gas is burned.

e By weighing the heated water on decimal scales in balanced buckets rather than measuring it in graduated beakers.

f By using filter papers to strain out the dust in preference to cotton filled tubes.

DISCUSSION

OUR PRESENT WEIGHTS AND MEASURES AND THE METRIC SYSTEM

By Henry R. Towne, Published in November Proceedings

Mr. H. H. Suplee Mr. Towne has presented the argument for a technical commission to investigate and report upon the subject of weights and measures so effectively that no further testimony is needed upon that point. Certainly anyone who was present at the recent hearings before the House Committee on Coinage, Weights, and Measures will agree that the subject should be placed in the hands of a more highly specialized body than was there possible.

2 It may be of interest, however, to place upon record, in the Transactions of the Society, the precise manner in which the metric system was actually adopted by the French Government, so that the members of the Society may have an opportunity of seeing just how that much discussed adoption was effected. I, therefore, give a complete translation of the law of July 4, 1837, referred to in the letter of the Minister of Commerce, in Appendix B of Mr. Towne's paper; this law still being in force, and being the statute which M. Domergue states that he has found impracticable to enforce.

3 This translation is made from the text as given in the important work by M. G. Bigourdan, of the Paris Observatory, entitled "*Le Système Métrique des poids et Mesures. Son Établissement et sa Propagation Graduelle, avec l'Histoire des Opérations qui ont Servi a Déterminer le Métre et le Kilogramme.*"

4 This work, which is the most complete and authoritative account in the French language of the origin and development of the metric system, gives in detail the discussions in the Chamber of Deputities and the House of Peers preceding the final passage of the law, and it should be consulted by anyone who desires the full particulars of the subject.

5 The law of the 18th Germinal in the Year III, of the French Republican Calendar (April 7, 1795) describes the metric system substantially as it exists today, provides for the establishment of

standards, and forbids the manufacture of the old weights and measures. This law contained no compulsory enforcement clause.

6 The law of the 19th Frimaire of the Year VIII (December 10, 1799) defined the standard meter and kilogramme to be those deposited with the *Corps Législatif* by the Academy of Sciences, reaffirmed the remainder of the law of 18th Germinal, Year III, and ordered the striking of a medal to commemorate the event; but still failed to include any enforcement clause.

7 The Decree of February 12, 1812, issued by Napoleon, was intended to meet the objections to the metric system, and provided for the use of certain fractions of the metric units, to be known by the old names, the foot being one third of a meter, but divided into 12 inches; a pound equal to one half kilogramme, but divided into 16 ounces, etc. With these brief explanations, the law of 1837 is given.

8 Projet of the Commission of the Chamber of Peers of France, passed by both chambers of the French Government, becoming law on July 4, 1837.

Article 1 The decree of February 12, 1812, concerning weights and measures, is hereby repealed.

Article 2 Nevertheless, the use of instruments of weighing and measuring prepared for use in accordance with articles 2 and 3 of the above mentioned decree, will be permitted until January 1, 1840.

Article 3 From January 1, 1840, all weights and measures other than the weights and measures established by the laws of 18 Germinal of the Year III, and 19th Frimaire of the Year VIII, constituting the decimal metric system, shall be forbidden, under the penalties included by Article 479 of the Penal Code.

Article 4 Those who shall have in their possession any weights and measures other than the weights and measures referred to above, in their warehouses, shops, workshops, or commercial establishments, or in the public markets, fairs, or bazaars, shall be punished, together with those who use them, according to Article 479 of the Penal Code.

Article 5 From the above date all denominations of weights and measures other than those contained in the table annexed to the present law, and established by the law of the 18th Germinal of the Year III, are forbidden in public acts, as well as in posters and advertisements.

They are also forbidden in all acts made under private seal, and in all commercial records or private writings to be produced in court.

Any violation of this law by public officials shall render them liable to a fine of 20 francs, which may be recovered by compulsion, as a matter of record.

A fine of ten francs shall be imposed for other offenders, this to be collected for each act or signed writing; each commercial record to be liable for but a single fine for each contest in which it may be produced.

Article 6 It is forbidden for any judge or arbitrator to render judgment or decision in favor of any individual upon any act, record, or writing in which the denominations forbidden by the preceding article appear, until the fines incurred in the terms of the said article shall have been paid.

Article 7 The inspectors of weights and measures shall ascertain any infractions provided by the laws and regulations concerning the metric system of weights and measures.

They shall proceed to seize the instruments for weighing and measuring of which the use is forbidden by the said laws and regulations.

Their reports shall be considered legal evidence unless proof to the contrary is presented.

The inspectors shall make oath before the court of the local magistrate.

Article 8 The manner in which the verification of the weights and measures shall be regulated by a Royal Ordinance.

* * *

9 Ever since 1840 the French Government has been endeavoring to enforce this law. With new industries, or in lines of manufacture or trade in which the work was not closely tied to the past, these efforts have been largely successful, but in the old established industries we see the difficulties by examining the letter of the Minister of Commerce, pleading with the Chambers of Commerce to come to his aid and try to induce the numerous industries which still adhere to the use of the old denominations to give up their illegal ways, and at the same time admitting his own unwillingness to disturb trade by enforcing the strict letter of the law.

10 I may add that Article 479 of the Penal Code, referred to above, is the provision of the Criminal Code against the possession or use of false weights or measures.

MR. FREDERICK A. HALSEY The only possible object of such a commission as that proposed by Mr. Towne is to introduce changes in our weights and measures. Clearly if the commission is to do nothing there is no occasion for its formation and to approve its organization is to acknowledge formally the possibility and tacitly the need of change.

2 Mr. Towne points out the unsatisfactory nature of the decimal basis of our system of notation, and I may add that a change in our notation is fraught with possibilities of improvement almost infinitely greater than could follow any conceivable change in weights and measures, but because of the difficulties involved in changing the existing notation he concludes that "it must be accepted as a finality."

3 With this I heartily concur, but just as he accepts our system of notation, so I accept our system of weights and measures. Like the decimal notation, it is not ideal—few human institutions are—but the difficulties of changing it are so vast, the certainty of failure is so obvious and the results would be so serious that I am absolutely opposed to any action which shall countenance it.

4 Mr. Towne's forceful argument against changing to the metric system has a far wider meaning than he gives it, for it is primarily an argument against not change to the metric system, but change to any new system whatever. Our wonderful uniformity, which as Mr. Towne points out is unique in the history of the world and not approached in any metric country, would be sacrificed by any change, and this uniformity is worth a thousandfold all the conceivable advantages that might follow any conceivable change.

5 The term "base unit" used by Mr. Towne, means nothing until it is defined, and he cannot define it in a way that will harmonize with his desire to have such units unchanged. The inch is the base unit of the machinist; the foot of the carpenter; the yard of the textile manufacturer and merchant; the grain of the prescription clerk; the ounce of the druggist's salesman; the pound of the butcher; the quart of the milk dealer; the gallon of the oil merchant and the bushel of the farmer. Which of these shall the commission decide to be the base units to remain unchanged while the others are changed?

6 The fundamentally greater difficulty of changing units of length as compared with changing those of weight and volume is well pointed out by Mr. Towne and has been pointed out by me elsewhere, but the difference is limited to the use of units in manufacturing industries. In the everyday commercial use of weights and measures there is no discoverable difference in the persistence of different classes of old units. The *libra* and *arroba* continue in use in Spanish speaking countries quite as persistently as the *pulgada* and *vara*, while the *livre* or half kilogram of France exists because it differs so little from the old Paris pound that in their everyday transactions the people did not know the difference.

7 Nothing is more certain than that the non-partisan unprejudiced commission which Mr. Towne has in mind is an impossibility. Every

man whose opinion is worth anything has his opinion formed already, and, regardless of the method of forming it, such a commission would inevitably resolve itself with a bi-partisan or possibly a tri-partisan body. Agreement among these elements is impossible. The history of the discussion shows the entire inability of the scientific party to appreciate the manufacturer's position. Until the recent appearance of Hallock and Wade's book the scientific party never so much as recognized that making things to measure differs in any manner or degree from measuring things as they exist and Hallock and Wade do not recognize it enough to hurt. Scientific men would enter such a commission with no object except to bring about the adoption of the metric system and the deference paid to scientific men today would introduce serious danger of their success. Were such a commission possible, the salary proposed is entirely inadequate to secure the services of competent men.

8 The final generalization from my examination of this subject is as follows:

No nation has ever made serious progress toward the adoption of the metric system in trade and commerce except by the force of compulsory law, and no nation has ever discarded its old units by force of compulsory or any other law.

9 There is no reason why progress toward the adoption of other new units should be easier or more rapid than toward the adoption of the metric units. Nothing is more certain than that the people of this country are satisfied with their present units and every reason advanced by Mr. Towne against forcing the people to use the metric units applies with equal strength against forcing them to use the new units which this commission must, if they do anything, devise. Universal compulsion in this matter is in this country unthinkable; success without such compulsion is impossible and failure means the destruction of our existing uniformity.

10 Our course in the future should be guided by the experience of the past, that is, by the experience of those countries that have attempted to change their weights and measures. The persistence of old units in so called metric countries and the resulting confusion is the answer to every attempt to introduce changes in weights and measures. In my paper "The Metric System," read before this society at the New York meeting of 1902, are a good many illustrations of this persistence of old units; in "The Metric Fallacy" are a good many more, and in the following letters which have been received since the publication of that book are still more. The circular letter of the French Minister of Commerce, Industry and Labor, given at the close

of Mr. Towne's paper, is the final official confession of a Frenchman of the truth of all that has been claimed by Mr. Dale and myself regarding the continued use of old units in France. Alongside of it should be placed the following extract from the reply of the Chamber of Commerce of Amiens, France:

11 "The Chamber after having the circular read was unanimous in recognizing that it is illogical in a country like our own, where the metric system has been in force for so long, that prohibited standards of weights and measures should still be in use; but the Chamber considers that in view of the customs adopted by certain traders, it seems difficult, if not impossible, to arrive at a complete suppression of the actual conditions; that, moreover, such a radical and immediate suppression would cause profound disturbance in many industries, notably textile manufacturing."

12 "Such a radical and immediate suppression would cause profound disturbance in many industries" and this at the end of 112 years of effort and 70 years of compulsory law! What more is needed to complete the rout of the metric party?

13 The letters from which the following extracts have been made have all been received during the past two years. They relate chiefly to countries not covered by the disclosures of "The Metric Fallacy" and are offered here as supplementary to those disclosures. They all come from countries which appear as metric countries in every standard metric list.

FROM R. E. MANSFIELD, U. S. CONSUL, VALPARAISO, CHILE[1]

14 "I have to say that, notwithstanding that the metric system of weights and measures is in operation in Chile, the following old units of measurement are still used here:

Vara (Chilian yard) = 836 millimeters, used by all retail dealers in selling drygoods.

Yarda (English yard) = 914 millimeters, used by wholesale dealers of goods imported from Great Britain.

Libra (pound) = 0 .4601 kilogram, used by retail dealers in selling groceries.

Galon (wine-gallon) = 3.7852 liters, used by wholesale dealers of barreled liquors imported from Great Britain and the United States.

Fanega = 97 liters, used in the purchase and sale of potatoes and other country produce.

Arroba = 11.5 kilograms, used by retail dealers in selling groceries."

[1]Chile first "adopted" the system in 1865.

FROM CHARLES C. GREENE, U. S. CONSUL, ANTOFAGASTA, CHILE

15 "The 'Metric System' is the only legal system for all purposes in this district and for all Chile. In some places the old Spanish measures are in restricted use, but in any question of law, all would be reduced to metrical equivalent. There is, however, one important exception; all contracts and quotations in Jackson Brothers' trade circular. The standards on the coast are in British sterling and weights. The Spanish quintal, that is for nitrate of soda, iodine, borax and etc., exported and certain staples imported, coal, coke, etc., but for Custom House entry these are all reduced to metrical equivalents."

FROM C. A. ORR, U. S. CONSUL, BARRANQUILLA, COLOMBIA[1]

16 "In reply to your letter of January 22, I have to state that it seems to be true in Colombia, also, that the metric system is not used by the people in trade and industry to the extent which one would infer. I am informed that the common people and retail dealers use very generally the English foot and inch; that the metric system is not used. In some of the small stores of this and I suppose other cities of Colombia, the Spanish 'vara' is used somewhat. Carpenters, masons and other artisans use the English system."

FROM ALBAN G. SNYDER OF THE U. S. CONSULATE GENERAL, BOGOTA, COLOMBIA

17 "The metric system is used here by all first-class people, and by the government as well in business of all kinds, but I am not aware that compulsory legislation exists as to its use, and if it does, it has not succeeded in preventing the use of old measures, for the merchants all use the yard as well as the meter, and retail merchants also use the Colombian measure, 'vara,' which is equal to 80 centimeters or 0.80 meters. This last named measure is used quite a great deal in ground measures as lots, farms, etc., for sale or purchase, in connection with the peasure or area called 'fanegada' which is generally four hundred fathoms square when applied to arable land, and 500 fathoms square applied to pasture land."

FROM E. H. DU BRUL OF CINCINNATI, WRITTEN AFTER AN EXTENDED TRIP THROUGH CUBA

18 "The Cuban Custom House gives out export figures on sugar and tobacco in kilos, but as a matter of fact, not a pound of sugar

[1] Colombia first "adopted" the system in 1857.

or tobacco is bought or sold in Cuba by the kilogram, but both are bought and sold by the Spanish arroba of 25 Spanish pounds.

19 The farmer who sells his cane to the sugar mill has the cane weighed up in arrobas and gets paid for his sugar in arrobas. The price of sugar in the sugar market is quoted in 'reales per arroba.'

20 The reale above is a monetary denomination that does not actually exist, it being 12½ cents in Spanish gold. There is no coin of this denomination. Tobacco is quoted in the same manner.

21 Lumber is bought by the Cuban from the United States by the English foot and is sold by the Spanish foot, or Burgos vara of three feet.

22 The Cuban and Spanish carpenter, cabinet-maker, mason, blacksmith, and other ordinary building trades in Cuba, work by the Burgos vara.

3 For instance a certain box of standard size used in a certain industry measures 21 Burgos inches square. Article after article was measured up by me with a rule that had both the metric and Burgos measurements, and the articles in common use invariably corresponded to the exact measurements by the Burgos rule, but would have made many odd millimeters if measured by the meter side of that rule. It appears that the mechanic uses the Burgos side of his rule in making chairs, beds, wardrobes, doors, windows, tiles for flooring and wall tiles as well.

24 The stone mason would use the Burgos rule. A civil engineer in the Government service told me that in laying sidewalks in Havana, the official regulation is ten centimeters thickness, but as a matter of fact the cement workers in laying the sidewalk turn their rules around and use the English side of the rule, because it is so much easier for them to figure three inches of rough concrete depth in the sidewalk and one inch finish, the proportion being ¾ rough and ¼ finish, the ten centimeters approximating very closely to four inches English.

25 The ordinary artisan is of course familiar with the metric measurements but the point is that he does not use them. He says that the Spanish measurements are more familiar to him, and as a matter of fact, he is compelled to use them in working around old buildings.

26 Sugar land is rented out to the farmers by the plantation owner not by the hectarea but by the caballeria, another old Spanish land measure.

27 Piece goods in drygoods stores are invariably sold by the vara and not by the meter. The merchants are under the necessity to continually translate their invoices from France and Germany, after

having imported the goods and declared them in the Custom House by the meter, into the vara, in order to calculate their cost and selling price on the same basis of measurement.

28 In Cuba nearly every rule sold by the hardware stores to the mechanics has the English, Burgos and metric measurements.

29 The English measurement is used extensively by workmen in machine shops, etc., because so much machinery in the island has been built either in England or America, and naturally in replacing these parts, they do not take the trouble to first measure them off in millimeters, but just naturally measure them up under the system according to which the parts were built.

30 From my own observation, and I can testify to the fact, that Cuba, although the metric system is officially the system of the country does not transact the internal business of the country in metric weights or measures. The people use the measures they are accustomed to in spite of the official pronunciamento as to the use of the metric system, and the Spanish system has simply been overlaid with the metric, causing endless confusion and transposition back and forth from one system to the other.

31 Civil engineers, surveyors and others whose work lies largely, in calculations like the metric system on account of its decimal arrangement, but those whose duties lie in construction and in the actual handling of physical things all use the vara of 36 Spanish inches for measurement and the arroba for weights."

FROM R. E. HOLADAY, U. S. CONSUL, SANTIAGO DE CUBA

32 "In reply, I have to say that upon careful inquiry and investigation, I find that while the metric system has been officially adopted in this country, as the standard of weights and measures, it is by no means in general use by the common people in trade. There are some trades, professions, and mercantile establishments, however, that have adopted and use the system to some extent. Notably, physicians, druggists, and pharmacists, surveyors, carpenters and brick masons.

33 Physicians use it almost exclusively in writing prescriptions and, of course, pharmacists are obliged to use it in compounding medicines.

34 In the building trades the old English system is principally used in the actual every day work, but in obtaining permits for the construction of buildings all estimates, plans, etc., are required to be submitted in the metric system.

35 Surveyors use the metric system in both public and private

surveys, but in surveying land they set forth the dimensions in the escritura (deed) in both the metric and Spanish system.

36 Grocers and provision merchants use both the English and Spanish systems of weights and measures.

37 Dry goods merchants use both the Spanish varas (yard) and the English yard, depending very much upon which the customer demands. If nothing is said the varas is always used which is a fraction over three inches shorter than the English yard.

38 From the above it will be seen that there are three systems of weights and measures actually in use here, English, Spanish and Metric. The English system is the one most commonly used in the actual every day commercial transactions, but both of the others are used in certain kinds of transactions.''

FROM MAX J. BAKER, U. S. CONSUL, CIENFUEGOS, CUBA

39 "The Metric system of weights and measures is established by law, and is adopted in all transactions at the Custom House, City Hall, and in the registry and records of property; in fact it is compulsory and adhered to in all official acts.

40 In the dispensing of all commodities, the common people are provided by retail dealers, in groceries all solid goods are sold by the ounce and pound, employing U. S. pound weights, as the scales are mostly of American manufacture, a few only being imported from Germany. Liquors are usually sold at wholesale in original packages, and at retail, by the bottle or fraction of a bottle, the poor people sometimes buying a few cents' worth.

41 The country's products such as cereals are sold by the pound or fraction thereof, except corn when sold in ears is sold by the fanega, which is 1,000 ears of corn. Vegetables are generally sold by the pound, the arroba or 25 pounds. Cabbages and bananas are sold in numbers from one up to one hundred or more.

42 Bakers employ dry wood which is sold by the cord. The cord measures 5.625 square Spanish yards. Coke is also used for cooking in ranges imported from the United States, Germany and France. It is sold at wholesale by the ton, and at retail by 100 pound bags. Laundries also use it. Wholesale drygoods merchants purchase their merchandise in Germany and France by the meter, in the United States by the yard, and they sell to the retail trade by the English yard, and the retailers sell to the consumer by the Spanish yard (called vara) and fraction thereof.

43 According to information obtained from master-builders contractors, and draughtsmen, they all agree that when they present

their plans and designs for official approval, they should be made in the metric system. Building materials, such as lime is sold in bags measuring 36 inches long by 15 inches wide. Bricks are manufactured here, measuring 12 Spanish inches long, 6 Spanish inches wide, and 2½ Spanish inches thick, and are sold by the thousand.

44 In all masonry work such as building of walls, all measurements are generally done by the superficial Spanish yard. In foundations the work is done by cubic Spanish yards.

45 Importers of lumber from the United States sell all their lumber by English yard measurement. Domestic lumber is sold by Spanish feet.

46 Civil engineers and land surveyors employ the metric system throughout their measurements. Mechanics in general make use of English inches as their unit of measures."

FROM HERMAN R. DIETRICH, U. S. GENERAL CONSUL, GUAYAQUIL, ECUADOR[1]

47 "The above, as said, are the official measurements used in the Custom House, etc. The general public, however, use various other measures for their transactions and these are:

For measuring lengths of goods in stores, the 'vara' about 33 inches. Also the 'pie', a foot of 12 inches is used in stores.

For liquid measure they also use 'liter' and 'botella,' by 'botella,' meaning a regular wine bottle. Also use 'gallon' which holds here the equivalent of about five wine bottles.

For weights the 'libra' or pound is used, 100 libras making one 'quintal' and the quintal is equal to about 101¼ American pounds avoirdupois.

48 The quintal is divided into quarters, each quarter being called an 'arroba' of 25 libras. As the building material used here is principally wood, the measurements in building are very simple, being made by the American foot of 12 inches, because all the imported wood comes from there and is invoiced to the importer by that measurement."

FROM ROBERT GRIMSHAW, AN AMERICAN ENGINEER RESIDING FOR MANY YEARS IN GERMANY[2]

49 "Although an enthusiastic advocate of a decimal, as opposed to a duodecimal or an octonal, system of weights and measures, and of the meter as a standard, as against the yard, simply because it is so

[1]Ecuador first "adopted" the system in 1856.
[2]Germany first "adopted" the system in 1870.

generally adopted, and not for any reason of inherent superiority, I must in reply to a prominent manufacturer give the facts as regards the use of the foot and the inch, together with a number of other equally antiquated arbitrary measures of quantity—in the German, Russian and Austrian lumber trade.

50 The usages vary with the district, and those for the import and export trade are also different from those used universally in domestic business.

51 In the districts of Königsberg, Memel, and Tilsit, English measures are used for foreign business (which is about all that there is) in Danzig, English, Rhenish, and old French feet and inches, and the meter. For trade to England and Denmark, the freight from the latter port is figured in English 'loads' of 50 cubic feet each. Posen uses the metric system, also the Rhenish foot, 32.346 cubic feet going to a cubic meter. The same is true of Berlin. Breslau has the metric system, but if feet are used, they are Rhenish. Magdeburg gets much rafted lumber down the Elbe, from Bohemia, and this is often measured by the Saxon 'ell' of two Saxon feet. Rhenish feet and inches and meters are also here employed. The 'shock' is sometimes used; the conversion being in the ratio of 270 meters—860 Rhenish feet—886 English feet to one shock. In Wien (Vienna) only metric measures are known, except in connection with staves, which are measured by French inches, of which 36 equal 976 millimeters. In Thorn the old 'zopf' is still used for standing and rough timber. In Hamburg the metric is the leading standard, but it is to be expected that in a port having so much trade with foreign countries there will be the necessity of taking cognizance of foreign measures, be these ever so ridiculous in their relations with each other. For foreign shipments freight may be reckoned in 'English freight measure,' 'gross measure,' 'caliper,' 'Queen's caliper,' 'gross caliper freight measure, etc.,' as well as in cubic feet. In Bremen the sole measure given in the official regulations seems to be metric, but no doubt it is here as well as in all other shipping and receiving ports, necessary to be able to convert metric into other units, and vice versa. In Triest, there are used the meter and also the foot; staves are measured in width by inches and in thickness by lines. There are, unfortunately, two kinds of inches, arising from the previous political relations of the province—the Viennese of 26 millimeters and the Venetian of 30. Bromberg has the metric system alongside of the Rhenish; logs in the water are measured by the old Rhenish 'Kettenmass' or chain measure. In Riga, Russia, where of course the meter is also legal, planks are measured by the 'standard' of 165 English cubic feet.

The 'Hobelgesellschaft' or Union of planing mill proprietors, uses as legal measures the meter and its derivatives, but decrees that where feet are used the relations shall be as 328 to 100."

FROM D. E. MCGINLEY, U. S. CONSUL, ATHENS, GREECE[1]

52 "During the last year a semi-official chart of the official weights and measurements of Greece was published, which gives the Greek measures and American equivalents. An examination of these tables shows that some confusion exists in these weights and measures, there being four 'piks,' two 'stremmas,' two 'kilons,' two 'dactylos,' and three cloth measures. The 'royal pik' is the length of the French meter, 39.37 inches; the 'mason's pik' is a little more than 29.52 inches; the 'endeje,' or small commercial pik, is slightly over 25.51 inches; and the 'bratzo,' or large commercial pik, is over 26.33 inches. The mason's pik is used in measuring mason work, and the last-named two piks for measuring cloth. The third cloth measure is the 'yard,' which lacks a fraction of an inch of the length of the American yard. It is used mostly in the Ionian Islands.

53 The stremma is a square measure, and the two stremmas in use are the 'royal' which equals a little more than 39.53 square rods and the 'old,' which equals a little more than 50.21 square rods. Why the old stremma is retained in use I have not learned. There are 4.047 royal stremmas in one American acre.

54 The two 'kilons' are measures of capacity, the 'royal' containing over 3.53 cubic feet and the 'old kilon' 1.171 cubic feet. Another measure of capacity is the 'hekatolitrom,' which is exactly the size of the royal kilon.

55 The trades use the metric system principally, but there are exceptions, as the use of the pik and yard by tailors in measuring cloth. Timber and boards are measured by metric, English and Venetian measures.

56 The unit of weight is the oka, which equals 2.82185 pounds. Up to the time the chart above mentioned was issued, the Greek oka was variously stated to be equal to 2.8518 pounds, 2.84 pounds, and 2.6998 pounds, but the official measures printed on this chart show that the oka is 2.82185 pounds in weight. I have been informed that in the Ionian Islands 2.6998 pounds is considered an oka.

57 For heavy weights the royal kilon, commonly called a 'kilo,' and equalling 75 okas, or 211.6987 pounds, and the 'tonos' (ton), equalling 2,204.6 pounds, are used. Wine, beer, liquors, oil, milk,

[1]Greece first "adopted" the system in 1836.

vinegar, syrups and other liquids are sold by the oka, on the mainland of Greece, but in the Ionian Islands the 'secchio,' 3 gallons, the 'pagliazza,' 1.99 gallons, and the 'barile,' 17.626 gallons, are said to be still in use."

FROM ALFRED A. WINSLOW, U. S. CONSUL GENERAL, GUATEMALA CITY, GUATEMALA[1]

58 "I have to say that the yard measure is more in use here than the metric system. The Spanish yard is generally used. As for weights, the pound is the most generally used."

FROM W. E. ALGER, U. S. CONSUL, PUERTO CORTES, HONDURAS

59 "Though some years ago Congress decreed that only the metric system should be used, it has never gone into effect, except in customs and there only weights are used, duties being based on kilos, while wharfage and other charges are on pounds. All units on lumber, etc., are same as in the United States. In the retail of drygoods, both yard and vara are used and understood by all."

FROM DEAN R. WOOD OF THE U. S. CONSULATE-GENERAL, CIEBA, HONDURAS

60 "The metric system has been officially adopted by this Government, and is used in all Government work. It is, however, never used by the people and merchants in trade.

The weights and measures used by the merchants here are the same as those generally used in the United States from whence most of the scales, etc. used here are imported. In selling groceries, etc., the same pounds and ounces are used as in the United States, and in selling liquids the same pints, quarts and gallons. In selling such articles as corn the 'arroba' is often used. The 'arroba' is equal to 24 pounds. In selling cloth the Spanish vara (33 inches) is sometimes used."

FROM JOHN H. RICHARDSON, U. S. CONSUL, UTILLA, HONDURAS

61 Upon the Bay Islands the English standard of weights and measures is used. I know of no use of the metric system."

FROM ALEXANDER HIMGARTNER, U. S. CONSUL, CATANIA, ITALY[2]

62 "I give below some of the weights and measurements in use. As an illustration of the annoyances of the old systems (and it seems

[1]Guatemala first "adopted" the system in 1895.

[2]Italy first "adopted" the system in 1845.

impossible to eradicate them) the 'salma,' a wine measure, differs in adjoining towns, and what is more remarkable, in some parts of the Island, values are estimated in the old money unit of 'onza,' divided into 30 tari of 20 grams each, the onza equaling lire 12.75.

In the small trades the liter is universally employed.

WEIGHTS AND MEASURES IN USE

Rotolo (divided into 32 onza) = 793 grams
Libra = 317.368 grams
Canna (8 palmi), 1 palmo = 0.258098 meter
Cantara = 79.342 kilos
Tumolo (grain) = 17.193
Miglia = 1 kilometer, 486 meters, 64.34 centimeters
Salma = 2 hectoliters and 75.89 liters

FROM BEN JOHNSON, SUPERINTENDENT OF MACHINERY, MEXICAN CENTRAL RAILWAY[1]

63 "The happy condition of things in Mexico as to the metric ystem (portrayed by F. Susteric in the 'Engineering and Mining Journal' of April 27, p. 808) is so far different from that prevailing in the shops under my direction, and from anything that has come under my notice in others, during four years' service in Mexico, that I have been prompted to make inquiries as to the practice of the principal railroads and commercial plants of Mexico.

64 I wrote to the heads of the mechanical departments of five of the most important railroads of the republic, all of whom answered to the effect that as far as all shop measurements of gages, drawings of locomotives and cars, and of other apparatus made in shops, is concerned, the metric system is unknown and English measures are used entirely.

65 The manager of one of the most important commercial shops in the republic (who has been for 25 years, and is still doing important engineering work) assured me that the same condition exists in his shop. One of the most prominent manufacturing firms, owned and conducted by Mexicans, writes me: 'In regard to the metric system, will say, that in our shops we use both the metric and English systems. In fact, all of our calculations of strain of materials, and floor plans, are based on the metric system, while the sizes and dimensions of material, lathe work, etc., are based on the English method.'

[1]Mexico first "adopted" the system in 1862.

66 All reports and plans for submisson to the government are, of course, made as requested by law, in the metric system.

67 The 'illiterate Indians' may have adopted the metric system; but if there is any important machine shop that has done so for its own use in construction work, I have yet to learn of it.

68 I think that the fullest investigation will sustain the opinion I have just expressed and will be glad to submit the original letters, referred to above, to your inspection if of interest."

FROM CHARLES E. WESCHE, VICE-CONSUL, CIUDAD JUAREZ, MEXICO

69 Here at C. Juarez and other border towns the carpenter and builder carries and uses his 'two foot' rule, and all building material is bought and sold by the same measurement which is prevailing in the United States. The drygoods merchant measures his wares by the 'vara' (33 inches) when dealing with the natives, while in his traffic with Americans he buys and sells by the yard. In the fuel trade fire-wood is sold by the cord and coal by the ton. Liquor dealers sell by pints, quarts and gallons."

FROM CHESTER DONALDSON, U. S. CONSUL, MANAGUA, NICARAGUA

70 "I have the honor to enclose your list marked as desired, and report that although the metric system has been officially adopted by the Government of Nicaragua, it is not used in practice, either by merchants, farmers or mechanics.

Cloth is sold by the Spanish vara = 33 English inches.

Railroads are measured by the English mile.

Sugar, etc., by the pound avoirdupois 16 ounces = 1 pound.

Surveyors use, as a rule, Spanish measurement.

FROM H. A. GUDGER, U. S. CONSUL-GENERAL, PANAMA[1]

71 "The official standard of this Republic is the Metric Sytem of weights and measures. In everything of an official character this system must be used. In buildings as well as the sale of land the same system is used. In buying and selling the merchants no not use this system. In other words, while it is the officially recognized system, yet it is not in common use."

FROM REV. GEORGE D. RICE, U S. NAVY CHAPLAIN, PHILIPPINE ISLANDS[2]

72 The information regarding the Philippine Islands is obtained from a letter from Rev. George D. Rice, a United States army chap-

[1] Panama as part of Colombia "adopted" the system in 1857.

[2] The Philippines Islands first "adopted" the system in 1850.

lain stationed in the Philippines. This letter will be found in full in a hearing before the Committee on Ways and Means of the 58th Congress, relative to the Tariff Laws of the Philippine Archipelago, dated Ferbuary 10, 1905. From it the following extracts are made:

73 "The mixture of the Spanish vara used here with the English, Filipino, and other systems of measurement is quite bewildering. The meter of the metric system is also used with the local standards. There are many Chinese, Hindoo, and some German merchants, and they have introduced various systems of measures. The common people, when left to themselves, use the straight Spanish tables of measurement, as the Spanish have published these for them. The vara is understood by all. The metric system is used in the railway service, the custom house, and other Government offices. The railway, however, is controlled by the Spaniards. The storekeepers, carpenters, masons, artisans, and others generally use the Spanish measurements. I have always heard the boss carpenters and others in charge of work give directions regarding dimensions to the workmen in Spanish terms and according to the Spanish tables. Occasionally a school-trained worker speaks of inches, feet, yards, and etc., but not often. The same condition is found in land measurements by the farmers. A friend explains to me how many square yards he has purchased from a native land owner, and then in addressing the natives uses the native terms entirely. Farm produce is measured out in square wood boxes marked with Spanish measures.

74 The Spanish and Filipinos have queer methods for measuring material in bulk. The Chinese follow suit. Instead of metal quart utensils one sees square wooden boxes numbered as shown in figure 6. Letters of figures corresponding to the Spanish or Filipino standards are stamped or burned on them to indicate how much rice, grain, flour or other dry stuffs they will hold. The boxes are often soiled and cracked, but all are tested as to the contents and passed by the inspector so that correct measurement is assured. Sometimes the entire outfit is made up of tubes of bamboo, all properly stamped with burnt letters and certified to by the inspector of weights and measures of the Archipelago. No undersized utensils are permitted. If any are found they are seized and the owners fined."

FROM W. F. DOWNS, A MINING ENGINEER RESIDING IN JERSEY CITY, N. J.

75 "I have just returned from a stay of ten months in Porto Rico. While there I had frequent occasion for annoyance over the confusion of weights and measures in vogue.

76 Distances on the government road are stated in kilometers and official surveys are given usually in meters, etc., but the Porto Rican land owner gages his land by the old Spanish acre or queida and sets the price accordingly.

77 In the stores goods are sold by the pound and you must watch to see whether you get a Spanish or an English pound. In the towns the price will sometimes be given by the kilo though cattle are bought and sold by the arroba. Drygoods are measured by the vara though you can also buy by the yard and meter. In the coffee and sugar districts many use the quintal as the unit of weight of goods in bulk.

78 As for tools I saw very few, but such as I noted in the hands of native mechanics, such as squares, rules, etc., were all divided into Spanish inches."

FROM C. L. MAXWELL, U. S. CONSUL-GENERAL, SANTO DOMINGO

79 "In replying to yours of January 21, 1904, I have to state that the American measures and weights are in general use here. In drygoods they use the Spanish vara for the yard, equal to 34 inches American."

FROM A. W. LITHGOW, ACTING U. S. VICE-CONSUL, PUERTO PLATA, SANTO DOMINGO

80 "The Dominican Government collects its duties, based on the English yard and pound. Drygoods are sold at wholesale by the English yard, but the retailer sells the same by the Spanish 'vara' which has 33 English inches. Provisions are bought and sold by the English pound. Produce of the country is bought by the kilo, calculating one kilo as two pounds. All the lumber used here is imported from the United States, so the English measures are used in the building trades, with very few exceptions, use the metric system."

FROM JOS. BOWRON, U. S. CONSUL, CARTHAGENA, SPAIN[1]

81 "The great bulk of retail transactions (probably 95 per cent) are done in the old weights and measures. Drygoods are sold by the yard or palmo ($\frac{1}{4}$ yard); wine, grapes, rice, etc., by the arroba (=11.5 kilos); grain by the fanega, a measure (wheat runs 40 to 42 kilos per fanega). Many storekeepers quote 'per kilo,' as being bigger and more attractive; but knowing nothing about grams, they divide up the kilo by fractions of pounds.

[1]Spain first 'adopted" the system in 1849.

82 I know that lumber is generally sold by feet and inches. In foundries and machine shops (few in number and unimportant), I understand that the metric system is used as a matter of convenience. Architects, bricklayers, etc., use the metric system in the larger towns; but in the smaller places the measurements are made in feet and inches.

83 Land is described, in official documents, in metric terms, with the equivalents in the old fanegas, tabullas, and celemines. Fuel is sold by Castilian quintals, of 46 kilos each. Flour for domestic use is usually sold per cuarteron = 6¼ pounds.''

FROM J. L. BYRNE, U. S. VICE-CONSUL AND DEPUTY CONSUL, VALENCIA, SPAIN

84 "The traditional systems of weights and measures still obtaining in this district in nearly all local or home commercial transactions on small scale are the most confusing and complicated imaginable."

FROM D. R. BIRCH, U. S. CONSUL, MALAGA, SPAIN

85 "I consider it best to preface the following by the statement that, generally speaking, the matter is largely a question of education. The principal stores in the center of this city adhere to the metric system almost without variation, the drygoods stores selling by the meter and the grocery places by the kilo. But even in these stores a person desiring purchases by the pound or yard, as the case may be, could be accommodated.

86 On the outskirts of the city proper or in the nearby villages, the metric system is but little used, its place being taken solely by the yard and pound, respectively. The Spanish yard (vara) is 0.836 meters and the Spanish pound (libra) equals 460 grams, but is currently rated as a half-kilo."

FROM LOUIS GOLDSCHMIDT, U. S. CONSUL, LA GUAIRA, VENEZUELA[1]

87 "The metric system is very little used in Venezuela, except by the Government when calculating the duties upon imports or exports to and from this country. All duties paid are according to the weight of the article imported, and the weight must be stated in kilograms, and the duties are usualy a certain amount per kilogram. This is about the only application of the metric system in practical use. In ordinary trade the old system is still in vogue,

[1] Venezuela first "adopted" the system in 1857.

and although the imports of merchandise are frequently expressed metrically, all local trade is according to the old Spanish systems of pounds, or varas (yards), etc. The weights and measures of Venezuela areas follows:

Arroba (dry)	25 .4024	pounds
Arroba (liquid)	4 .263	gallons
Fanega (dry)	1 .599	bushels
Pound	1 .0161	pounds
Vara	33 .384	inches

Quintal equals 100 Venezuelan pounds.

88 Although most goods which are imported, generally are put up according to the system of the country of their origin, they are sold (even by the first importer) according to the usage of this country. Drygoods, which may be put up in meters or yards, are never sold in that way, but are figured over into varas, and the bills are made out accordingly. And so with other merchandise, excepting, possibly certain building material or timbers, which are usually invoiced according to the measurement of the country of their origin."

* * *

89 When opening their campaign before the House Committee on Coinage, Weights and Measures in 1901, the metric party based their case on the following assertions:

90 *a* The metric system is in universal use in all civilized countries except the British Empire and the United States. In reply this assertion has been turned to ridicule.

91 The appendix to the report of the Committee of the 57th Congress contains a list of forty-three countries which are there stated to have adopted the metric system and this list has been republished far and wide as representing facts. In "The Evolution of Weights and Measures and the Metric System" by Hallock and Wade, is a table showing "the time at which metric measures were first adopted; when made compulsory, and, so far as can be ascertained and briefly stated, the extent to which they have replaced other and older measures."

92 From this table *twelve* of the countries which appear in the standard list are bodily omitted, in eight others the use of the system is admitted to be negligable and of four others the column giving the extent of the use of the system is blank, while of other countries the statements made are untrue. $12+8+4=24$ which is more than half of 43. Query: Have Messrs. Hallock and Wade learned anything from "The Metric Fallacy"?

93 *b* The adoption of the system is a necessity for the promo-

tion of export trade. In reply it has been shown by the overwhelming testimony of exporters of machinery (in which Mr. Towne concurs above) that the call for the system in foreign trade in negligable.

94 *c* The adoption of the system would simplify our weights and measures. In reply it has been shown that the only effect of its adoption would be to superimpose a new set of units on the old ones, introducing far worse ratios than those that now obtain and thus complicate our system.

95 *d* The adoption of the system would lead to a saving of from two-thirds of a year to a year (sometimes stated as from two-thirds of a year to two years) in the school life of every chlid. In reply it has been shown that the entire time devoted to denominate numbers and weights and measures in the public schools of New York City aggregates less than six weeks, which the addition of a new system to the old one would increase and not diminish.

96 *e* The adoption of this system would introduce uniformity in our weights and measures and in reply it has been shown that we have now a degree of uniformity that is unapproached in any metric country and that this uniformity would be destroyed by the adoption of this system.

97 *f* The adoption of the system is an easy matter, the length of the transition period being seriously estimated by a dozen prometric witnesses before the Committee to lie between two and five years. In reply it has been shown that, in spite of the most drastic compulsory laws, the transition period is not yet over in any metric country, France included, and that in countries having laws similar to the one proposed here, there has been little and in some cases practically no progress toward its adoption in trade and commerce.

98 Had the metric party gone before the House Committee on Coinage, Weights, and Measures at the start with the rags and tatters of a case that remain to them, the Committee would not have been justified in listening to them for an single hour.

Rear Admiral Geo. W. Melville I have read with much care the admirable paper by Mr. Towne, and I want to say that, in the main, I agree with almost every word he says, but unfortunately I dissent from his conclusion that it is desirable to appoint a commission to consider this matter of weights and measures.

2 I am quite familiar with the efforts which have been made by various parties to force a bill through Congress, making the use of the metric system compulsory, and indeed have appeared before the House Committee on Coinage, Weights, and Measures and have also

written them on the subject. It seems to me that Mr. Towne, in his desire to be absolutely fair to everybody, has hit upon this scheme of a commission, which at first glance seems an admirable method for arriving at correct views on the subject.

3 I am rather inclined to think that before the hearings on the metric system I should have been quite ready to approve the idea of a commission to consider this subject, but the testimony which was given before the commission, and the attitude of mind which it showed as existing on the part of many men classed as scientists, makes me doubt very gravely whether the scheme for a commission would work out well.

4 It used to be one of the boasts of men who call themselves scientists that they of all men were absolutely fair in their investigation of a subject, that their great motto was truth, and that their whole effort was to ascertain and propagate the truth irrespective of personal or other considerations. The showing which the scientists made in the discussion of the metric system is certainly calculated to make the judicious grieve and to prove most conclusively that there are scientific bigots as well as theological ones.

5 To any unprejudiced person the published testimony must have shown with unmistakable clearness that the scientific men were not actuated by a desire to ascertain the truth, for the reason that after incontestable facts had been presented by competent experts as to the enormous cost and inconvenience of making the change they continued merrily to assert that the change would excuse a little inconvenience and so small a cost that both could be waived aside.

6 Scientific truths are not limited to more or less close guesses at distances of remote heavenly bodies, but include data of a financial and economic character when based on careful investigation and deduction from a sufficient number of reliable examples. Mr. Towne's paper is so calm and judicial in tone and states so well the real merits of the whole question of weights and measures that any further discussion of that side of the case seems unnecessary. I have said what has gone before to show my fear that if a commission were organized, some of the members would certainly be people who came with anything but open minds and who had proved conclusively that they are not prepared to discuss the matter in a really scientific spirit. It would seem to me, therefore, that however the commission is chosen, we would be almost sure to get a divided report and we would be just where we are now.

7 Further than this, it seems to me that Mr. Towne's own paper shows in an admirable way that there is no necessity for an elaborate

investigation as to the desirability of a change. In the case of weights and measures, as of so many other things, the Anglo Saxon race has shown itself capable of handling the problem intelligently. The advocates of the metric system have made a great parade of the alleged enormous number of units to be remembered in English systems of measure, but Mr. Towne has shown in paragraph 89 that as a matter of fact, although the tables in the text books give a large number of units, the actual ones which are used are very few in number and are all of great convenience.

8 It seems to me that if we who believe the existing systems of weights and measures to be satisfactory, agitate for a commission to consider the subject, we are going even further than the case of a man who proposes to submit to arbitration the question of whether he has not an equal right to the watch which you have bought and carry. We think that absurd, but to ask for this commission is almost to hunt for a man to agree to arbitrate whether our watch does not belong to him.

9 Our experience in the United States has shown that in the long run we get substantially what we find to be best. We all know how the provision of the Constitution relating to the choice of the President by electors has been practically nullified so that the President is really elected directly by the people. We still go through the form of choosing electors but they are bound to vote for the candidate of the party with which they are connected. Different lines of work ultimately come to use the unit of weight or measure which is most convenient for them, and they do not wait for government authority or encouragement to do so. We have found by experience that the units of length, which on the whole are of most use are the mile, the yard, the foot and the inch, as stated by Mr. Towne. The other units in the tables have practically dropped out. In the same way in the United States, our units for weights in general are only the pound and the ton.

10 Our own society has a set splendid example in its consistent endeavor to secure uniformity and standardization where such were desirable and beneficial, and we have always found that where a real benefit could be shown to result, manufacturers were willing to incur considerable expense. My feeling is, and has been right along, with respect to the metric system, that if it became desirable to adopt it our people would do so under the permission already granted by law and would not need to be driven into it by compulsion.

11 Is it not worth remembering also that, while the Committee on Coinage, Weights and Measures, consisting as it does almost

entirely of lawyers, is not a body of experts competent of themselves to pass on such a highly technical subject as this, nevertheless the scheme in a general way is somewhat like that of the jury system. There, if technical questions are involved, experts are called to testify and the jury decides after listening to their evidence. The Committee has considered this subject now for a long series of years and, although at one time when the opponents of the compulsory use of the metric system had not had an adequate opportunity to present their side of the case, the Committee did report recommending such adoption, they have recently, after about four years of careful hearings of both sides, reported against it. Whatever the report of the commission, I do not believe it would settle matters at all. If it were so organized as to have a majority of scientific bigots we might anticipate a report recommending the adoption of the metric system. This would not convince the manufacturers and they would oppose any bill for such compulsory adoption just as strongly as they have already done.

12 On the other hand if there were a majority of manufacturers on the commission they would almost certainly report against any compulsory change in existing weights and measures. This would not satisfy the scientists, who would continue their propaganda with the same fanatical zeal which has characterized them hitherto.

13 While not agreeing with Mr. Towne that a commission is desirable, I wish again to express my high appreciation of his paper which I consider a very complete and judicial presentation of the case, which sets forth the whole matter in very clear shape, and which is especially to be commended for its fairness.

MR. JAMES CHRISTIE The creation of a technical commission as proposed by Mr. Towne, and as embodied in the Lilley bill, cannot fail to meet with the approval of the greater number of those who are interested in the subject of national standards.

2 Most of the proposed legislation on the subject has been wanting a stable foundation, and an intelligent comprehensive report by a commission that would duly consider all the phases of the question would tend to give a rational basis to future legislation.

3 It will not do for the few radicals of either side to attempt to decide the subject in an *ex parte* manner, as we can now see that the question will be periodically agitated. The extended adoption of metric measures in applied science, and its extension thence to the closely allied arts, is gradually bringing the subject closer to the thoughts and observation of the masses of the community.

4 As a single illustration, take the chemical industries. The

adoption of metric measures in chemical science is resulting in its extension to the allied industries, and as the art of chemistry is constantly obtaining wider application, it would appear probable that there will be a gradual increase or spread of the metric system to industries associated with chemical science.

5 Our existing system of weights and measures is in a transitional stage, and the final result will be either that one method will be adopted to the exclusion of the other, or some compromise will be suggested that will command international support, or else we will have in existence two concurrent systems of weights and measures, which unfortunately bear no satisfactory relation to each other.

6 The respective merits and demerits of both systems under review, has been so amply expressed elsewhere, that repetition is needless. I might, however, state that the passage of years impresses on the writer that the clear mental image of the relation between large and small quantities when expressed in the decimal system is so manifest and desirable, and the absence of a similar mental conception in our system forms a sharp contrast in merit, from this point of view alone.

7 International uniformity is very desirable as a means of facilitating interchange of products. Leveling processes now in active operation will tend to obliterate the causes, which in the past have offered effective resistance to free exchanges, and it is good business policy to remove all restraint possible when other interests are not sacrificed.

8 Mr. Towne has stated his views very lucidly, and they form an interesting addition to the anti-metric argument.

MR. WILLIAM KENT Mr. Towne's valuable paper is a very important addition to the literature in antagonism to the adoption of the metric system by the United States. I do not see how any unprejudiced person (if any such person exists as far as this question is concerned) can read this paper without being convinced that the adoption of the metric system in this country to the exclusion of the English system is not only undesirable but also impracticable and impossible.

2 I am not sure that I favor at this time the appointment by the Government of a technical commission on the subject, but I certainly should favor the appointment of such commission rather than the passage of any other legislation whatever in regard to the system. It might be well to hold Mr. Towne's proposed bill until the next pro-metric bill is introduced in Congress and then

have his bill for a technical commission introduced as a substitute. Let the two bills, for the metric system and for a technical commission, both be referred at the same time to the Committee on Coinage, Weights, and Measures and let that Committee report on each and on whether one of the two bills should be passed by Congress.

3 Mr. Towne makes some suggestions in regard to improving the English system and therefore this subject is open for discussion in connection with this paper. In regard to the "needless confusion" in the English system (paragraph 17), the confusion is not so bad as the metric advocates try to make it out. The pound troy and the apothecaries' pound are never used in commerce. The troy ounce is the unit for weighing gold and silver. Apothecaries' weight does not exist outside the prescription department of drug stores. On their sales counters the drug stores use the avoirdupois system and there is no such thing as a pound weight in the apothecaries' system to be found in any drug store.

4 The grain is rarely used in practice and it would be a good thing to discontinue its use entirely and substitute another weight, the 10,000th part of a pound = .7 of a grain. I have found it necessary in some work involving fine weighing to use the metric system simply because it was a decimal system and then convert the results back into avoirdupois weight, just because I did not have a set of avoirdupois weights divided decimally. An ideal system would be the avoirdupois pound with binary subdivisions down to one-eighth of an ounce and also decimally into hundredths, thousandths and ten-thousandths of a pound.

5 In regard to measures of volume (paragraph 18) it would be well to abandon all our gallons and use a new gallon of 216 cubic inches, which is six inches cubed, or $\frac{1}{8}$ of a cubic foot. The pint would then be three inches cubed, or 27 cubic inches, or $\frac{1}{64}$ of a cubic foot. The bushel might also be abandoned and the cubic foot used instead, or if it should be considered that the word "bushel" should be retained, it might be defined as $1\frac{1}{4}$ cubic feet or 2,160 cubic inches, or ten new gallons. This would only be 9.58 cubic inches more than our present American bushel and 58.19 cubic inches less than the British bushel.

6 In regard to measures of length, the furlong, rod, and rood are already practically obsolete. They are not needed in any industry whatever. The mile, foot, and inch are practically all we need, the yard being scarcely ever used by engineers except in cubic measure, but it will undoubtedly be retained for measuring textiles and no good purpose would be served by trying to get rid of it.

SAW-TOOTH SKYLIGHT IN FACTORY ROOF CONSTRUCTION

By Mr. Fred S. Hinds Published in October Proceedings

Mr. Samuel M. Green Mr. Hinds has not brought out in sufficient relief to be of use to one first attacking the problem, the troubles pertaining to saw-tooth skylights. I shall attempt to show in the following what these troubles are, to point out some of the faults of Mr. Hind's design, and describe what I consider the best methods and details of design to meet these troubles.

2 In all my remarks I refer only to the saw-tooth roof as used in the textile industries, as the requirements in this field are far more exacting than in any other.

3 The excellent lighting qualities of the saw-tooth skylight are well known to those who have had experience with it, but the person who has never been in a building properly lighted by this method has a surprise in store, as north light has a very penetrating power and under it, imperfections of surface or texture are readily discerned.

4 The advantages of the saw-tooth form of skylight lighting over the ordinary skylight depend entirely upon the requirements of each case. If either north light is desirable, or the direct rays of the sun are objectionable, or as usually happens, both requirements exist together, then the saw-tooth is the only solution of the problem. But if these requirements do not exist, then I think the skylight of the ordinary form is preferable.

5 Practically all the troubles of the saw-tooth skylight are caused by severe winter weather conditions of our northern climate, and can be classed under two heads: leaks caused by severe outside conditions, and inside condensation caused by low outside temperatures.

6 Rain, of course, will find any ordinary hole or crevice. Snow and ice cause water to back up and find imperfections that otherwise would not cause trouble. Snow and ice will freeze on to the roof and cause the roofing material to pull and sag. Frost will get under nail heads and pull the nails out.

7 Recently, in connection with my work for a prominent woolen company in Massachusetts, I was called upon to design a weave shed for 900 looms. This concern already had in operation a large shed, which I am informed was the first saw-tooth weave shed built in this country. It was of the English type and possessed all its faults, except as they had been partly cured by the mill management.

8 The first move I made was to see what other mill engineers and architects had done. During severe winter weather I investigated some of the more recent sheds belonging to the most prominent textile concerns in the north, and I must say I found that very little progress had been made to get at the real cause of the many difficulties and annoyances from the saw-tooth construction.

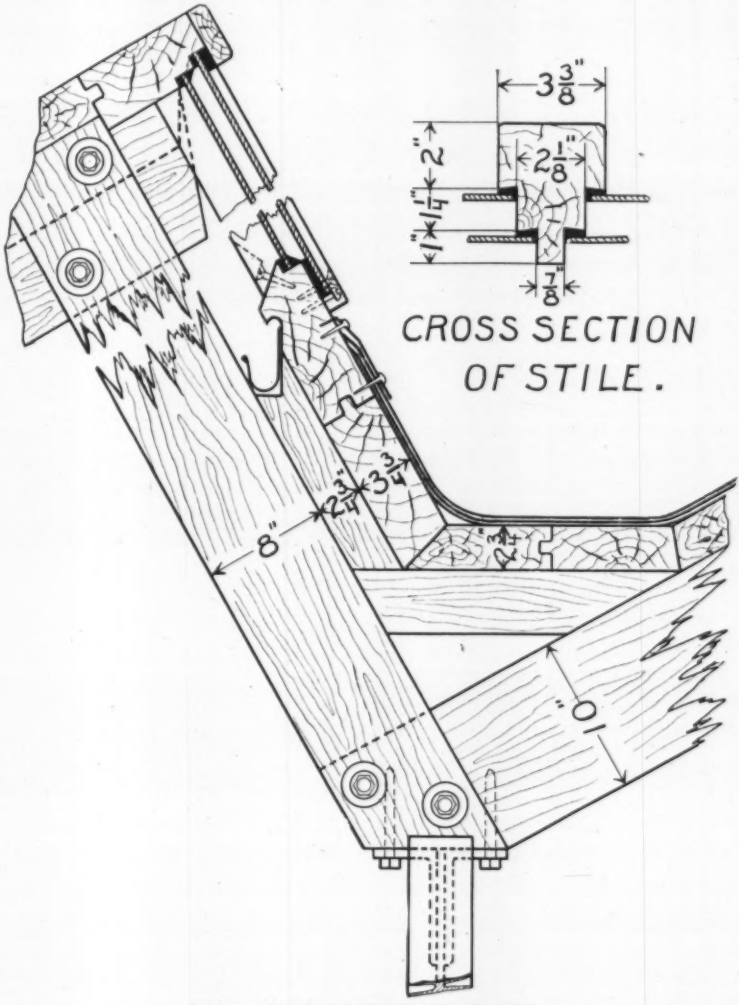

FIG. 1 CROSS SECTION OF GUTTER

9 Evidently architects had not had practical experience in the maintenance of their designs and had not benefited by their failures. I was, however, connected with a superintendent who had for years carefully noted the troubles, and had made strenuous

efforts to overcome them, and it was largely due to his suggestions that I was enabled to design a roof that I believe practically meets all the difficulties.

10 I will take up Mr. Hind's paper in paragraphs. (Par. 5) It is not correct to say that the principles of the saw-tooth skylight is to focus the light. On the contrary, the best results are obtained by the use of factory ribbed glass, which diffuses the light, giving all parts of the room equal strength of light. The amount obtained is, of course, a function of the glass area and the floor space of the room to be lighted.

11 (Pars. 8 and 9) The concern previously referred to, built as early as 1880 what Mr. Hinds calls the Americanized type, which consists, as I understand it, of a flat gutter instead of a rounding one.

FIG. 2 EXTERIOR OF TEXTILE MILL, SHOWING SAW-TOOTH SKYLIGHT ROOF CONSTRUCTION

12 (Par. 11) To explain more fully the troubles of the metal gutter, the test of the English type of gutter, and in fact any other design, is winter weather. Changing temperatures cause the metal to expand and contract until it breaks and then leaks. The worst condition with snow is when it melts, then freezes, and then melts again under the ice, thus causing the water to back up hill, as it were. This water will discover any aperture at cap flashing on the glass side, or between the metal gutter and roofing material, on the other side.

13 In our northern climate the sharp gutter was found impossible at once by all the first users of it, and the change to a flat gutter roofed with the regular roofing material, was made simultaneously by several companies.

14 The company mentioned, as early as 1880, built an addition, using the wide flat gutter. The old roofs that they first had were

covered with slate on the flat side. This they removed and replaced at various times with many kinds of prepared roofing material, all of which failed.

15 (Pars. 12 and 16) Too much pitch to the gutter is not possible. One-half inch per foot is none too large but usually is all that can be reasonably obtained. It is a mistake to try to carry all the water to the end of the skylight or gutter. It is better to put in an ample number of down-takes for the roof water, at intervals along the length, carrying them down inside the building.

FIG. 3 INTERIOR OF MILL, SHOWING SAW-TOOTH SKYLIGHT AND PIPING PROTECTED BY GALVANIZED IRON SHIELD

16 (Par. 14) A 60 degree angle of glass I have found highly satisfactory in the north. I have never experienced any trouble from the direct rays of sunlight, especially if factory ribbed glass is used. In this connection, the angle at the ridge of the roof should be 90 degrees or more, in order that the light will not be thrown against the inside of the roof. I would not hesitate to make the angle of the glass 55 degrees and that of the ridge 95 degrees.

17 (Pars. 19 and 20) The elimination of all cross beams that cast shadows is a necessity in textile work and can always be done by using sufficient posts, if the requirements will allow. The use of a rod for the lower member of the truss, in place of a beam, is

FIG. 4 INTERIOR VIEW OF SAW-TOOTH SKYLIGHT SHOWING CONSTRUCTION OF VENTILATOR DAMPERS

a good idea, although this beam does not interfere with as much light as a beam running parallel with the roof.

18 (Pars. 22 and 25) In the north, double glazing, on account of its better heat non-conducting qualities, is preferable to the single. The only serious objection is the difficulty of repair.

19 These paragraphs refer to the greatest weaknesses of the design described by Mr. Hinds. He passes lightly over the problem of condensation. In textile work a high degree of humidity is maintained with the result that in cold weather condensation on the glass is very great. This is especially objectionable in a weave

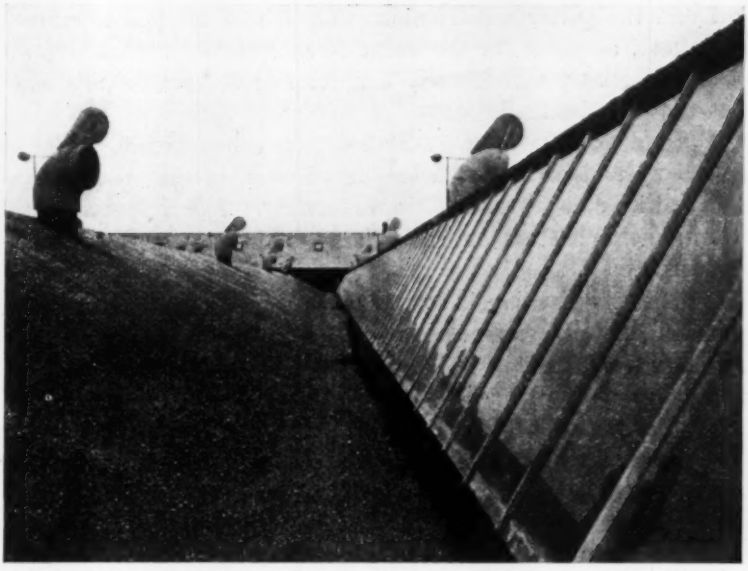

FIG. 5 SHOWING ROOF AND COVERING OF SAW-TOOTH SKYLIGHTS

shed, for the reason that even a drop of water on a sized warp will cause exceedingly bad work. The objection to Mr. Hinds' method of taking care of this condensation is that the holes he provides for letting this water outside will collect an icicle and freeze, with the result that the gutter fills and runs over into the room. These holes also allow a large amount of cold air to leak into the room. The proper method is to remove this water by means of inside gutters.

20 To determine the value of one of the much advertised forms of metal-bar skylights, for saw-tooth work, I installed a small section, with the result that the lower ends of the bars, on the inside, were covered with very heavy frost and the aperture to allow the

water of condensation to escape froze up. Of course these faults barred the design from consideration.

21 The principal advantage of the metal construction over wood is the ease of installation. Its disadvantages follow: Metal is a better conductor of heat, therefore causes condensation. Particularly the upper and lower horizontal members of the metal skylight, on account of coming in contact with both the outside and inside air, are a very great source of annoyance, through becoming condensers.

22 The horizontal members are long, are therefore badly affected by expansion and contraction, and it is difficult to make a satisfactory joint between the lower horizontal member of the skylight and the gutter construction. Mr. Hinds' method is entirely inadequate, as water, in the event of snow filling the gutter, will certainly back up through any counter and bottom metal flashed joint that can be made.

23 (Par. 26) The slat walk must have a bad wearing effect on the roofing and in a way defeat its purpose, in that it holds the snow and ice and prevents its rapid melting. The supports for the walk will hold moisture and cause decay, both in the supports and in the roofing.

24 The better method is to make the roof good enough so it can be walked on, and also so that snow will not have to be removed except in case of a blizzard, in which case a board walk will not prevent damage from shovels.

25 (Par. 38) The fact that wood sash are being removed in some places and metal sash substituted only indicates that the owners have been convinced that their troubles are going to be cured by the substitution. I am inclined to think that their troubles will be augmented.

26 The design described in the following has proved almost faultless to date.

27 It will be observed from the accompanying illustrations that the building is of semi-steel construction. The posts are steel I-beams, being anchored to concrete piers, and extend in one piece from piers to roof. The wood floor beams rest on, and are bolted to, I-beam stringers, the stringers in turn being riveted to the posts. The floor planks are 4 inches thick, thoroughly spiked to floor beams, and at the wall ends are bolted to steel angles, which in turn are bolted to the brick walls. This construction makes the floor very firm, and at the same time sufficiently elastic for high speed heavy looms.

28 The tying together of the roof and the posts is accomplished by light steel channels and angles, which form the shafting supports. The usual method for belting looms is from below the floor; in fact,

it is absolutely necessary to so belt them for some classes of goods. The method causes less obstruction of light but when possible, I think the advantages of the overhead belting over the under-floor belting, more than equal the disadvantages.

29 Fig. 1 is a detail of gutter, glass, and ridge construction. The pitch of the gutter is made by light cross pieces on top of the roof timbers. The curb is of 4 inch pine, the top of which is beveled at a sharp angle, to permit the water of condensation to readily run off the curb, and it is also grooved to form a drip edge for the water to drip into a small copper gutter, which gutter is connected by means of a lead pipe to the regular roof down-take.

30 The gutter proper is made as follows: The corners formed between the bottom of the gutter and the curb on one side, and the gutter and the flat roof on the other, are filled with a fillet of wood of curved shape. Then sheet asbestos, $\frac{1}{16}$ inch thick, is laid, extending up to within 3 inches of the glass on one side, and 2 feet on the flat roof on the other side. On this asbestos is then laid galvanized iron of about No. 24 gage, extending to the same heights. This galvanized iron is nailed down. The object of it is to make the gutter firm to walk upon and to cover up any imperfections in the plank, especially, as when the plank shrinks it will cover up the cracks, thus preventing the felt being broken when walked upon. The asbestos prevents moisture from the room reaching the galvanized iron, condensing, and dripping back into the room.

31 After the gutter is so prepared it is then ready to receive the regular five-ply asphalt or pitch roofing. It is well to lay an extra ply in the gutter, to increase the strength. The roofing should be thoroughly nailed and mopped. On the glass side, it should be brought up to within about 2 inches of the glass. To protect this edge of the roofing, a flashing of galvanized iron was used, the edge of which was bent and sharpened and then driven into a cut in the curbing made by a special tool, shaped like a calking tool. Then it was nailed, with 1 inch spacing of nails, at the top and bottom. Slag, on account of its lightness and porosity, and consequent better holding qualities, was used to cover the gutter and flat portion of the roof. The curbing under the glass was thoroughly mopped, up to the glass.

32 The stiles or bars were made of white pine, firmly fastened to curb and ridge with brass screws. Both curbing and stiles were shellaced inside and out before painting. The painting throughout was with pure white lead and oil.

33 The glazing was double, the inside light being $\frac{1}{4}$ inch factory ribbed and the outside being plain double-thick glass. The

outside glass was held from slipping downward by means of brass screws. Both lights were thoroughly puttied with 33 per cent white lead putty.

DRAINAGE

34 Roof down-takes were spaced about sixty feet apart to enable the gutters to empty themselves quickly. The down-takes are 4 inch copper pipes, carried down to the basement floor within the building posts, the posts for the down-take pipes being of a "built-up" channel section, whereas the regular posts are I-beams.

35 To prevent condensation, the copper roof bowl was covered with plastic magnesia and the down-take pipes were wrapped with asbestos. This piping was protected from damage by means of a galvanized iron shield seen on the first post to the left in Fig. 3.

VENTILATION AND HEATING

36 A weave room, especially for wool, should be thoroughly ventilated, first, to give healthful conditions, and second, to give even humidity throughout the room. In this room ventilation was accomplished by means of two steel plate blowers, each driven by a motor, the entire equipment being located in the basement. Their combined capacity being equal to a ten minute air change.

37 It was so arranged that air could be drawn either from out of doors or from the basement, and air could be cooled by coming in contact with artesian well water. The air is discharged into the room in fifteen places, at a height of about 8 feet above the floor line, and is allowed to leave the room by means of innumerable openings near the floor line, into the basement, by four revolving ventilators in each saw tooth and by the windows. These arrangements permit all fresh air to be used or all foul air or any mixture of the two desired.

38 Roof ventilators have been a source of great annoyance on account of the condensation that occurs inside them and the difficulty of making them tight at the roof line. To prevent the former, both the stationary part of the revolving elbow were double walled, making 1 inch air spaces. To care for the latter, the roof joint was made tight with a copper flashing, the flat portion of which was large in area and was placed before the roofing was laid. The upper edge of the circular portion of the flashing was hammered over and soldered to the top edge of the stationary part of the cowl.

39 To close the ventilators, a damper of special design was made, which hermetically seals them. The construction of this

damper is plainly shown in figure 4. It is nothing more or less than a stopper having a soft packing and controlled by a lever and rope. The connection between the rope and lever is by means of a spring so that there is a constant pressure exerted against the packing.

40 This damper has not been entirely satisfactory, for the air will work its way through the packing, condense in it, and drip back.

41 Heating is by direct radiation, two thirds of the pipes being on the wall near the floor, and the balance at the ceiling. For some unaccountable reason, indirect heating has been much used for recent weave shed work but I have yet to see an indirect system that was satisfactory and economical. In my investigation I did not find one mill manager or superintendent who was at all satisfied with his indirect system.

SUMMARY

42 The lighting qualities of the saw-tooth roof skylight cannot be improved upon. Progress has been extremely slow to improve the mechanical defects of this skylight. The main points of the design I have submitted are:

a Careful gutter design and construction to prevent leaks.

b No metallic connection between inside and outside air; therefore no uncontrolled condensation.

c Careful provision to remove the water of condensation on the glass.

d No uncontrolled openings between the inside and outside, which let in cold air.

e Minimum obstruction of light.

f The use of factory ribbed glass, which diffuses the light so that what slight obstruction there is becomes unnoticeable.

43 Referring to Professor Sweet's discussion, I doubt not that the design used at the Straight Line shops is satisfactory for a machine shop, but I am very sure that it would not answer for textile work on account of the condensation on the cast iron gutters.

44 I should like to know just the exact detail that was used by Professor Sweet to prevent leaks in the joints between this gutter and flashing on one side, and roof on the other side.

Mr. L. H. KUNHARDT What I may say in discussion of the papers presented on this subject is simply one of endorsement of the type. Even today the value of good light in manufacturing plants

is not sufficiently appreciated, that is, sufficiently so as to force in every case an intelligent study of the conditions. In the ordinary factory type of two or more stories I can give many instances of plants recently built where the tops of the windows are from two to three feet below ceilings and pilasters nearly as wide as the win-

TABLE I

DISPOSITION OF SAW-TOOTH ROOFS BY STATES AND APPROXIMATE DATE OF ERECTION

	NO. OF FACTORIES INSURED	NO. HAVING SAW-TOOTH ROOFS.	NO. HAVING SAW-TOOTH ROOFS PREVIOUS TO 1900.	NO. HAVING SAW-TOOTH ROOFS 1900–1906 INCL. TO DATE.
Canada	90	2	0	2
Maine	72	0		
New Hampshire	88	3	0	3
Vermont	24	2	2	0
Massachusetts	502	22	5	17
Rhode Island	137	14	3	11
Connecticut	200	13	8	5
New York	277	15	5	10
New Jersey	146	29	16	13
Pennsylvania	250	43	28	15
Delaware	12	1	0	1
Maryland	13	1	0	1
Virginia	14	1	0	1
Ohio	61	6	2	4
Kentucky	6	1	0	1
Michigan	17	2	0	12
Indiana	9	3	0	13
Wisconsin	19	1	0	11
Illinois	30	4	0	4
South Carolina	47	2	0	12
Georgia	12	1	1	10
Alabama	13	1	0	1
Tennessee	5	1	0	1
	2044	168	70	98

Of the 70 before 1900: 6 were built between 1870–1880; 15 or 16 between 1880–1890; 15 or 16 between 1890–1895; 31 between 1895–1900, and nearly all of these 31 after January 1, 1898.

dows, when there was no reason why the top of the sashes should not have been practically at the ceiling and the pilasters occupying less than one third the wall space, thus allowing wide windows.

2 The application of saw-tooth roofs ought to be more general, as the distribution of light is superior in every way, in fact it was stated to me in one case that on a dark day or toward evening,

it even seemed lighter inside the shops than outside, probably due to the more uniformly diffused light and the absence of shadows.

3 As illustrating the growith of this type I have taken for example the manufacturing plants, 2044 in number, to the value of $1,500,000,000 insured by the Boston Manufacturers Mutual Fire Insurance Co. and the other Factory Mutual Companies associated with it. Of these, some old factories, some new, but most all being extended more or less from time to time, 168, or over 8 per cent now have one or more buildings with saw-tooth roofs. They are divided among the various stated, as noted in Table 1. The number of these built since the beginning of 1900 is also given and it is worth stating that, of the 70 built previous to 1900, 31 were built between 1895 and 1900, and nearly all of these after January 1, 1898.

4 The growing favor with which these roofs are looked upon is therefore evident, and it must be noted also that there are many more such roofs on factories which we do not insure and of which I have not the data at hand.

5 In the effort to add to my own observations the experience of others, I communicated with many of the factories to learn of troubles or disadvantages, if any, and in general, practically all faults reported are either due to design or to faulty workmanship. As regards application, the testimony is almost uniformly favorable for weaving and similar processes in textile factories and for machine shop and similar work, such as assembling, drafting and in all places where best light is desired. In foundries and dye-houses there is more difference of opinion, but not sufficient to discourage the use, the main trouble being ventilation.

6 In general, the disadvantages are from leaks, poor ventilation, excessive heat, and condensation when roofs are of thin boards, or excessive condensation when rooms have considerable moisture in them, all of which can be obviated. I will give a few suggestions.

a Do not build the stories too low. Twelve to fourteen feet under the girders is in my judgment a minimum, and more is needed under many conditions. While a low story brings the glass and the light down nearer the work and makes less space to heat in winter, on the other hand the ventilation is distinctly poorer and the heat of summer more oppressive, due to the sun's rays directly on the sloping roof planks which are so near the heads of the employees.

b Design the saw-teeth to face the north, directly or not more than a few degrees to the east of north, as the morning sun for a short time is not so objectionable as the afternoon sun.

It is desirable to exclude direct rays of sun whenever possible. The saw-teeth can be placed to run diagonally on a building if it is necessary.

c Ventilation by a fan system is to be preferred, as otherwise the middle of these wide buildings do not get fresh air. Excellent results are obtained in weaving rooms having fans in dry basements taking the air from the basement and through windows and discharging it over the heating coils to the floor above. Metal ventilators of ample area at frequent intervals along the top of each saw-tooth are to be preferred to other methods of top ventilation, and these, in connection with the fans, will remove sufficient air to keep the atmosphere pure. I do not think ventilators alone are sufficient in these wide buildings; something is needed to keep the air moving. A combination of the fan system with direct heat may perhaps give best results. Pivoted or swinging sashes are apt to give trouble from leakage in driving storms, and dirt also blows in through them when open. In foundries and wet rooms very ample ventilation areas and good height are necessary.

d Leaks are a common fault, but can be overcome by maintaining a flat gravelled space of from one to not over two feet between saw-teeth, and by flashing high and insisting on good workmanship and materials. Continuous saw-teeth have less chance for leakage than a number of short ones, but on the other hand, when they run longitudinally on a long building they need to be broken up at intervals to allow access across roof for removal of snow in severe storms or for fire. By bringing saw-teeth to the side walls and extending the side walls up, the side windows become unnecessary and there are then absolutely no shadows. Condensation gutters with provision for carrying water outside have been obstructed by freezing if not properly designed therefor, and are sometimes drained to a point inside the building. The bottom of the sash should be horizontal and not follow slope of the roof.

e Galvanized iron sash I think are to be preferred to wood, as they are stiffer. The putty does not come out as in wood sash and the sash does not rot as any wood sash is inclined to do, especially when not vertical. All galvanized iron is, however, poor at its best and paint has to be depended upon to prevent rusting out. On this point practice varies. Wood sash is, of course, cheaper in first cost.

f Ribbed glass is to be preferred with ribs vertical and on the inside. The sloping glass in saw teeth probably keeps cleaner under the same conditions, both inside and outside, than vertical glass in the ordinary monitor roof.

g Saw-tooth roofs cost more but not so much more that the added expense is not fully warranted for all rooms where excellent light, well diffused, is to be desired. The cost of artificial lighting under ordinary monitor roofs or in rooms with side windows only is considerably more, due to the larger number of hours such light is required, and this is a fixed charge. As one man expresses it, he has "more light at less cost" under his saw-tooth roof.

h Roofs should be built of plank not less than 3 inches in thickness on wide bays—timbers 8 feet to 10 feet on centers. The light purlins or joists on heavy trusses 20 feet or more on centers ordinarily present no advantages over lighter trusses 8 to 10 feet on centers with plank spiked directly to them. The smooth roofs overhead are in every way the best. Hollow-in roofs are not necessary and only a very few factories have them; their use is not justified and the roof is, I believe, distinctly poorer. A good thick roof is cooler in summer and requires much less heat in winter than a thin one, perhaps more than a hollow one, but not, I think, enough more to make the use of hollows advisable when considering their undesirable features.

I also present a table showing the disposition of these roofs over various processes in the 168 plants noted in table 1.

7 I wish to add a word regarding fire protection. It is a recognized fact that roofs that have any wood about them in their construction will burn, as noted in the paper presented to this meeting by Mr. Alexander Brown of the Brown Hoisting Machinery

Company, and we might add a very considerable list of similar experiences to his. It is also a recognized fact that any occupancy of a plant which involves use of contents, combustibles in themselves, may involve at least partial destruction of buildings built practically of incombustible construction. Hence one of the fundamental

TABLE 2

DISPOSITION OF SAW-TOOTH ROOFS OVER VARIOUS MANUFACTURING PROCESSES

	TEXTILE						MET. WORKERS			MISC. IND'L PLTS				
	WEAVING, WINDING, ETC.			MISCELLANEOUS PROCESSES	BLEACH OR DYE WORKS		MACHINERY	FOUNDRY	MISCELLANEOUS	SOAP	LITHOGRAPHING, PRINTING	PAPER COATING	OFFICES, DRAFTING OR ENGRAVING	OTHERS
	COT.	WOOL	SILK		COT.	SILK								
Canada							1	1		1				
Maine														
New Hampshire					2		1							
Vermont	1	1												
Massachusetts	15			6			3							
Rhode Island	6	2	1		4			1						
Connecticut	7		3	3	1		3		1					
New York	1						7	5	1		2	1	2	
New Jersey	2	4	10	4		7	4	1	1				4	1
Pennsylvania	4	12	14	2			8	2			1			
Delaware							1							
Maryland			1											
Virginia	1													
Ohio			1	1			2	2					1	
Kentucky								1						
Michigan							1							1
Indiana							1	1						1
Illinois							2							1
Wisconsin														2
Southern States	5							1						
Total	42	19	30	16	7	7	34	15	3	1	3	1	7	6

The total of 190 varies from total of Table 1, due to some of the plants having various roofs covering distinctly different processes.

principles should be to provide protection ample for each individual case. In this way can be obtained extremely low cost insurance on industrial plants, which is and has for ten years been averaging from seven to eight cents per $100 of insurance and is just now less than this, and for the so-called fire-proof buildings, which in most

cases today are simply fire resisting, even these figures can be reduced.

8 I mention the question of cost of insurance especially of the latter type, as I believe it was stated a year ago at our meeting that insurance of these costs 30 cents, and I wish to urge upon all not to expect the building to protect the contents, but rather to provide protection commensurate with the risk, and obtain rates which make possible more than a good return on the additional investment, and at the same time make interruption or loss of business, which is more expensive than anything else, practically an impossibility. Nothing has yet or ever will equal the automatic sprinkler device for extinguishing fires, and I close these remarks with the oft repeated advice to "put in a thorough equipment of automatic sprinklers reinforced by adequate water supplies." You then have an ever present watchman always working in your interests.

SAW-TOOTH ROOFS FOR FACTORIES

By Knight C. Richmond, Published in November Proceedings

Mr. Samuel M. Green In my discussion of Mr. Hind's paper on this same subject I have given my experience and views on most of the points raised by Mr. Richmond. I wish to emphasize one or two of them however.

2 The consideration of the angle of glass, as related to the direct rays of the sun, is not nearly as important as Mr. Richmond's paper would lead one to think. Great care to secure the correct theoretical angle would be spoiled, in most cases, by the simple fact that absolute north exposure is seldom obtained, and as I have mentioned in the discussion of Mr. Hind's paper, the slight amount and duration of direct sunlight obtained by an approximate north exposure and by about a 60 degree angle of glass, becomes entirely unnoticeable when factory ribbed glass is used.

3 Proper proportioned forced ventilation will obviate the necessity of carrying a high degree of humidity in textile work and therefore reduces considerably the extreme condensation effects, particularly the necessity of using a heat insulating material on the roof other than 3 inch matched planking.

Mr. L. H. Kunhardt I will comment on a few of the points in Mr. Richmond's paper. My remarks regarding this type made in connection with Mr. Hind's paper might, however, follow either paper.

As regards paragraph 4, it is my belief that the saw-tooth type is also adapted to the heavy machine shops he mentions, especially so in shops having galleries on either side of the high center section over the cranes. This center section can be made of the saw-tooth type and the result is most gratifying, for without it there is apt to be a relatively dark space directly under the center and along the columns carrying the cranes.

2 Referring to paragraph 10, plank roofs without hollows are to be preferred, under practically all conditions, to those with hollow spaces. The light inflammable sheathing with spaces behind it is readily combustible and such condensation as may occur inside the space rots roof plank and the sheathing. If 3 inch roof planking is sufficient for flat roofs why not also for the saw-tooth form? Good circulation of air ought to prevent all possibility even of trouble, which, however, I do not believe is likely, except in wet rooms where condensation is bound to occur whether the room is under a roof or a floor of the story above.

3 Referring to paragraph 16, I would advise against furring up the roof under the covering. This provides the objectionable hollows again, and in even a worse place, under the valleys where leakage, if it occurs, will cause rotting. I would advise inserts on top of the timbers cut of varying heights, so that the roof plank when spiked to them may take the slope desired for the valleys. It is necessary, as stated in the paper, however, that the girders be all on a level, so that the room may be of uniform height under them, but it makes no difference if the planks of the roof are of varying height to provide slope for the valleys.

4 In paragraph 18, the mention of areas brings me to add one caution—that they should not be too large. Subdivision of a property is desirable, not only from an insurance point of view, but also from that of the owner. Does he himself wish to face the possibility of a single fire wrecking his entire plant as has happened in many cases, and in which also, had it been of two or three times as large area, all would have gone down in the destruction. Areas need to be of proper size for economical shop management, but there is a limit beyond which there is no gain, and perhaps, on the contrary, a distinct disadvantage. Yard space is fully as valuable as buildings, under some conditions, and there comes a time, even though sprinklers, as stated, overcome objections so far as rates are concerned, when insurance companies have to reduce their lines on account of the congested values in one area or fire risk.

A MECHANICAL ENGINEERING INDEX

By W. W. Bird and A. L. Smith, Published in November Proceedings

Mr. L. P. Breckenridge While the general scheme, as outlined in this paper, is in the highest degree commendable, the system of indexing seems entirely inadequate. Alphabetical indexing is, or should be, a thing of the past except for indexes of limited scope. The decimal system is superior in every respect, and is rapidly coming into use among engineers and engineering concerns.

2 For some years the Mechanical Engineering Department University of Illinois, has used an extension of the Dewey decimal classification with the most gratifying result. It keeps up a card index of current periodical engineering literature which now contains 20,000 cards. All these are indexed according to the decimal system. The same system is used for indexing catalogues, blue prints, photographs, lantern slides, etc.

3 In brief the advantages of the decimal system are:

(*a*) It groups allied subjects under one class number whereas the alphabetical system scatters them through the twenty-six letters of the alphabet.

(*b*) It prevents ambiguity and makes cross reference practically unnecessary.

(*c*) It is flexible and capable of indefinite extension.

4 Several years ago, the Mechanical Engineering Department, recognizing the value of the decimal system, prepared an extension of the Dewey System for Mechanical Engineering. This has passed through four editions. A fifth edition containing extensions for all branches of engineering is now ready for the press and will appear in the near future.

Prof. William Kent Messrs. Bird and Smith have done a service to the Society in publishing their valuable index. I have no time at present to study it in detail but hope to do it sometime in the future and for some years I have been hoping to write a paper on the same subject myself. I wish that special attention would be called to paragraph 6 on page 337, concerning standard sizes for catalogues. I wish there could be some way of fining any manufacturer who brought out a catalogue of any other size than one of these standards. A confusion of size in any shelf of catalogues gives rise to no end of trouble to everyone who attempts to keep a file.

THE EVOLUTION OF GAS POWER

By F. E. Junge, Published in November Proceedings

Mr. H. E. Hellmund Mr. Junge has brought forward in his paper a series of new possibilities for the utilization of energy which is being lost at present, which decidedly deserve the attention of every engineer. In almost every problem of power utilization, including the methods proposed and cited by Mr. Junge, electricity forms an important factor as means for transmitting the energy from the place of its generation to the place where it is needed. It is obvious, therefore, that the system generating the energy should be well adapted to work in connection with the system of transmission and vice versa.

2 Reviewing the numerous cases mentioned by Mr. Junge, in which a satisfactory combination of energy generation by gas engines and transmission by electricity may lead to considerable advantages, one cannot help but feel sorry, that at the present time the electrical engineer is, as a rule, inclined to avoid the use of a gas engine in his plants as much as possible.

3 At the same time I realize, of course, that these prejudices are not quite without reason. Only about five years ago I found that after gas engines of one of the best makes had been adopted as prime-movers for the direct current power plant of a small German town, much trouble was experienced, because the gas engine (100 k. w.) stopped about once a week in consequence of preignition. Although a battery was provided it was not able to carry the maximum load of the day, and therefore the fuses of the battery blew out and the whole town had to be in the dark for about 10 or 15 minutes. It is obvious that these results are not very apt to influence a power plant engineer to introduce gas engines and unfortunately these early experiences are liable to retard the introduction of the gas power even when the difficulties mentioned above are practically eliminated.

3 I am pleased to state that the gas engine has been improved so rapidly, during the last five years that there is not the least objection to their use in direct current plants. In alternating current plants some difficulties are still experienced. It is a fact that synchronous alternating current machines, which work perfectly satisfactorily in connection with steam engines, quite frequently cause trouble in consequence of hunting, if they are used in connection with gas engines; this is due to the fact that the angular velocity

of gas engines, especially that of smaller units, varies as a rule more than that of steam engines. It must be admitted, however, that in most cases where trouble on account of hunting is experienced, it could have been avoided by the choice of the right make of gas engine and by the choice of the right kind of alternating current machines, *i. e.*, machines with good and effective anti-hunting devices.

4 This is proved by the fact, that quite a number of alternating current plants with gas engines as prime-movers operate very satisfactorily. If power transmissions with gas engines as prime-movers are built, is it necessary that the nature of the gas engine be taken into consideration, when the transmission system is projected. It is, therefore, also advisable, in order to avoid troubles in consequence of hunting, to use motors of the induction type instead of synchronous motors, as is frequently done in case of larger units. Although it is true that the use of induction motors increases the line losses to a certain amount, it should be remembered that in most cases this disadvantage is made up several times by the greater economy of the gas engine compared with the steam engine.

5 If as Mr. Junge suggests in paragraph 75, a number of smaller independent producers furnish energy into the network of a larger central station, it might be even advisable that induction motors driven above synchronism are used as alternators in the plants of the smaller producers, while the main plant is equipped with synchronous alternators.

6 This would have the advantage that the smaller producers would not need to have as high grade men as would otherwise be necessary. Such a system would, of course, only be possible, if the load of the system is always larger than the amount of energy delivered by the smaller consumers into the line.

7 It is beyond any doubt that much can be accomplished along the lines indicated by Mr. Junge, if the engineers building gas engine plants keep in close touch with electrical engineers and take care to get the apparatus best adapted to work in connection with their plants.

MR. W. D. ENNIS There seems to be divergence of opinion as to the relative costs of the installation of steam and gas power plants. Mr. Junge argues that the higher first cost of the gas plant may be disregarded. An article by Mr. W. Schomburg, in the "Elektrotechnische Zeitschrift" is quoted in a recent number of the "Electrical Age," which gives $112.50 and $135 as the respective costs per kilowatt.

This certainly does not correspond to American practice. The Boston Elevated Railroad found the gas plant to be about 75 per cent more expensive. A recent magazine article stated the difference to be 42 per cent. Probably from 50 to 75 per cent is the average difference in this country for plants of equal size, the wide variation being due to the fact that no two people figure alike as to just how much refinement of detail is justifiable. This is a serious handicap for the gas plant.

2 Mr. Junge gives figures representing the best Continental practice. He reports producer efficiencies up to 85 per cent. Schomburg gives 75 to 80 per cent, less 10 per cent for stand-by losses. Mr. Bibbins, in his paper presented at this meeting of the Society, reports a maximum of 71½ per cent. It would not appear, therefore, that we, on this side, have as yet exceeded, if we have equaled, the efficiency of the steam boiler.

3 Neither have we obtained any such thermal efficiency with our gas engine as 38.6 per cent. The best result given in Mr. Bibbin's paper is 1.5 pounds of coal (13,500 B. t. u.) per kilowatt hour. Assuming efficiency of producer and line to have been 70 per cent, of generator and leads 93 per cent, and of engine mechanism 87½ per cent, the thermal efficiency of the engines was 29.6 per cent. The Boston Elevated Railroad reported a 30 day run on 1.31 pounds of coal per kilowatt hour. Assuming 14,200 B. t. u. in the coal (Pocahontas), and efficiencies as before, the thermal efficiency of the engines was 32.2 per cent.

4 If we accept 38.6 per cent as the best as yet obtainable with gas, what is the outlook for the steam engine?

5 Professor Hood, in his paper on the new record breaking steam engine performance, presented at this present meeting, quotes an efficiency, as compared with the Carnot cycle for the conditions, of 73.69 per cent. To equal the gas engine standard, assuming that we cannot increase this figure, we must work in a Carnot cycle having an efficiency of $38.6 \div .7369 = 52.4$ per cent. At the present time, our best practicable vacuum is 28 inches, corresponding to a temperature of 100 degrees. With this as the lower temperature of our cycle we must, in order to secure an efficiency of .524, employ steam at an initial temperature slightly over 700 degrees. Temperatures higher than this were observed by Professor Carpenter, according to his paper on the White motor car engine.

6 We have therefore obtained in two separate trials, two results, which, if secured concurrently, would give us an efficiency equal to the best as yet claimed for the gas engine.

7 There is one important point in connection with these record breaking figures. Professor Hood's engine shows a thermal efficiency of 25.1 per cent. It may be a long struggle from this point to the 38.6 per cent of the gas engine; no doubt it will be a struggle for other gas engines as well as for the steam engine. But the practical desideratum is to work up to these efficiencies, rather than to work up beyond them. With the vast majority of our engines, even in good plants, having a thermal efficiency not over 10 or 12 per cent, there is a possibility of a gain of 100 per cent by reaching Professor Hood's figures; beyond that, even up to the gas engine record, the possible gain is only 50 per cent. What we need, in both boiler and engine practice, is not so much new record breaking efficiencies as a nearer approach to these efficiencies in ordinary plant operation; and this is getting to be more and more a matter of load factor, so far as the engines are concerned; and of air supply regulation, in boiler operation.

MR. R. C. CARPENTER The paper by Mr. Junge is a valuable one for the reason that it calls attention in a brief and concise manner to the principal epochs in the development of the internal combustion engine and to the characteristics and advantages of the various working cycles which have been invented from time to time.

2 The reference to the work by the American inventor and engineer, Mr. George B. Brayton, should not be without interest to the American Society of Mechanical Engineers; due to the fact that the cycle which he invented possesses theoretical and practical advantages over the Otto and has essentially the same characteristics in practical operation as that of the Diesel which differs, however, theoretically, and was invented much later. The Brayton cycle is one in which ignition takes place at constant pressure, whereas the theoretical Diesel cycle, as described in his patent, is one in which ignition takes place at constant temperature; practically, however, the Diesel engine more often operates on the constant pressure or Brayton cycle than on the constant temperature or Diesel cycle.

3 In connection with the suit brought for infringement of the Selden patent for use of a gas engine on a motor car, a thorough investigation has been made of the work done by Mr. George B. Brayton in developing his internal combustion motor, which proves that Mr. Brayton occupied a position, both theoretically and practically, much in advance of his time. As his life and work must be

of great interest to American mechanical engineers, I will call attention briefly to some of the work which he accomplished.

5 Mr. Brayton was granted four patents for his internal combustion engines. The first, dated in 1872, was for a gas engine, in which the gas and air were drawn by suction into an air compressor in proper proportions for a combustible mixture and were there compressed to the desired pressure and delivered into a reservoir, from this reservoir the combustible mixture was fed into the working cylinder where it was ignited. A cut-off valve controlled by a governor shut off the supply at the proper time to produce uniform speed. A concontinuous flame was maintained in the working cylinder which was fed from the reservoir through a small opening. The constant pressure gas engine of Brayton's was used quite extensively and a test was made by Dr. R. H. Thurston which is published in the report of the Vienna Exposition of 1873. This engine proved to be troublesome to maintain, principally due to the difficulty of preventing the flame passing back from the working cylinder into the reservoir filled with combustible mixture of gas and air and causing an explosion. Because of this difficulty Brayton was led to design a new engine in which oil was the source of fuel instead of gas, which was patented in 1874. It operated in much the same manner as the engine of the 1872 patent, but the air compressor was used for the purpose of compressing air only and the oil was injected by a special pump directly into a vaporizing chamber which was closely connected and an essential part of the working cylinder.

5 The Brayton oil or hydro-carbon engine was built by several firms in this country, each of which was given a limited territory to supply. Several hundred motors were made and were used for a great variety of purposes. The engines designed for stationary purposes were generally built with an inverted walking beam arranged to connect the working cylinder and the air compression cylinder. These engines were exhibited at the Centennial Exhibition in 1876, pumping water and driving machinery. One of these engines, of 3 h.p., was used by Dr. Draper in his investigations of the properties of light in 1877–8, and is still in existence and is owned by the complainants in the Selden patent case referred to above.

6 Another engine of 5 h.p. was used by Prof. Anthony in 1875 in a lecture before the Cooper Union, to drive the first dynamo machine, of the Gramme type, ever built in America. This latter machine was afterwards bought by Cornell University and was used by that institution for several years for furnishing the power for the Physical Laboratory. It is still in good working condition and forms

a part of the equipment of the Mechanical Laboratory of Sibley College.

7 The Brayton engines in operation were comparatively noiseless and gave an indicator diagram much like that from the Corliss engine. Brayton considered these engines as "combustion" engines rather than "explosion" engines because of the smoothness of their operation, which was due to the peculiar character of the combustion. The Brayton engine was designed to operate at the maximum pressure of 60 to 80 pounds, and for these conditions its economy was very poor, being much inferior to that of the unmechanical free piston engine which was built by Otto and Langen. The actual efficiency on the basis of heat converted into work, in accordance with Clerk, was seven per cent when gas was used and six per cent when oil was used, the low efficiency being very largely due to low pressures, to friction, and losses between the air compressor and working cylinder. The efficiency of the Otto-Langen engine was from 50 to 100 per cent. better than that of the Lenoir engine only about one-half as great.

8 There is abundant evidence to prove that Brayton constructed his engines in numerous forms, as for instance, double acting engines with separate compression cylinder; single acting engines with the combustion chamber in one end and the compression pump in the other, walking beam engines, the cylinders in some cases above and in other cases below the walking beam.

9 The engines were applied for the propulsion of boats and were used commercially for this purpose. They were also applied for the purpose of propelling a street car and operating a bus. No commercial success attended the application to the street car or to the bus.

10 The early engines of Brayton were of the two cycle class. In 1890 he patented an engine of the four cycle type of which a limited number were built. A test of one of these engines was made by Mr. Dugald Clerk which shows great superiority of the early type.

11 Mr. Brayton died in 1893. The above concise statement of his work indicates that he is entitled to a prominent place in the development of the gas engine and recent investigations indicate that his cycle is likely to be extensively used in the future. I hope that a full description of his life and machines will be presented to the Society at some future meeting.

BOILER AND SETTING

By A. Bement, Published in November Proceedings

Mr. L. P. Breckenridge The experience of the writer confirms that of Mr. Bement, namely that the tile roof furnace with a chain grate stoker appears to be a most satisfactory combination for the burning of many grades of western bituminous coals without smoke and with good economy. For years engineers and builders of boilers have been told that one of the fundamental requisites for smoke prevention was that the gases evolved from the fuel should not come in contact with the cold tubes or boiler plate until complete combustion had taken place. Nevertheless, little attempt seems to have been made by parties designing or building boilers or boiler furnaces to meet this requirement.

2 Builders of boilers have for years furnished plans for setting their boilers. They complacently say that they do not build stokers or furnaces but that any of the various kinds of stokers may be used successfully with their boiler. Parties building stokers or furnaces are equally ready to sell you their goods assuring you that they will give satisfaction under any of the standard types of boilers.

3 This method results disadvantageously to the purchaser. He does not know whom to blame for poor performance. It would seem that the time had come when a single manufacturer should sell the entire outfit consisting of boiler and furnace.

4 If this were done, we might then hope for better results for the purchaser. The alert builder who is soon ready to put on the market that combination of boiler and furnace which will burn bituminous coals without smoke and with an overall efficiency of even 75 per cent, both of which are entirely feasible, would be doing a great service to the purchaser of small or medium sized power plants, which must depend on bituminous coal for their fuel supply.

5 Is it not strange that the owners of power plant boilers are compelled to modify the standard settings as purchased in the market in order to meet the demands of the smoke ordinances or to increase their economy? The strenuous competition in most lines of design such as pumping engines, gas engines, turbines, generators, and electric motors has created appliances of high efficiency. The same thoughtful planning in the field of boilers, boiler settings, and furnaces would certainly be followed by the same satisfactory results.

6 At present there is an attempt to find some particular variety of coal of the right size which will burn in the furnaces now in use Should we not endeavor to decide what types of furnaces, settings,

and boilers may be depended on to burn the representative coals which are available.

7 A question which naturally presents itself in this connection is, what length of tile roof furnace is necessary for any kind of coal, or, how high above the grate should this roof be placed?

8 More than 460 trials of coals have been made under steam boilers at the Government Fuel Testing Plant at Saint Louis. In very many of these tests careful data have been taken of temperatures and gas analysis in the fuel bed over the fire, at the bridge wall and at the rear of the combustion chamber. It is evident from these tests that in the case of some fuels, combustion is complete one foot above the fuel bed while for other fuels the combustion is not completed at the rear of the combustion chamber.

9 In all these tests a tile roof furnace has been in use, as is usual with the Heine Boiler used in these trials. The writer hopes to soon present to the Society a review of this extensive series of trials. There are now available at the office of the Director of the United States Geological Survey, Washington, D. C. several publications relating to this work.

Mr. W. D. ENNIS This paper offers a remedy for a condition which is quite familiar to anyone who has operated water tube boilers of that type in which the path of the flue gases is parallel with the tubes. In such boilers, as usually set, if there are more than about eight rows of tubes running vertically, the gas passages are too large in proportion to the grate; and if we keep down to eight rows of tubes, we usually find that the boiler heating surface is too small to take up all of the heat that it should; so that we are apt to have to contend with either the short circuiting of the gases or deficient heating surface.

2 I have recently come across an exaggerated instance of this difficulty. The quotient of grate surface by gas passage area at successive points, beginning with the bridge wall, was 2.9, 6.2, 3.9, 4.8, 6.2, 3.5 and 11.8. With these boilers, having a ratio of heating surface to grate surface of 47 : 1, we can get as much as 13 per cent of CO_2 (although we cannot quite average that), but when burning upward of 18 pounds of coal (slack) per square foot of grate per hour we cannot hold the flue gases below 700 degrees. In this case we have insufficient heating surface, short circuiting, and badly related gas passage areas to contend with.

3 This question of capacity of boiler heating surface to handle high rates of combustion came up about two years ago in a western plant which I visited where California oil was the fuel. We had

some horizontal boilers built for burning wood. The boilers had four-inch tubes. We had to force them somewhat, and the flue gas temperature was high. We made six tests and found an average evaporation of 14.05, generating 3.76 pounds of steam per square foot of heating surface per hour. (The individual figures for evaporation ranged from 13.5 to 14.7 pounds.) Then we put retarders in the four-inch tubes; had the blacksmith twist them out of $\frac{1}{8}$ x 4 inch iron, and made five more tests. Our evaporation was from 14.9 to 16.0, with an average of 15.4, and a rate of steam generation of 3.96 pounds. As this gave us a pretty high efficiency, 80 per cent average, we checked the matter very carefully. As far as the forcing was concerned, we could not find that it made any difference. Our efficiency was just as high at 3.96 generation rate as it was at 3.0. This was a clear case of avoiding short circuiting through those big tubes.

4 We had a Babcock and Wilcox boiler in the plant, on which we ran two tests. Our highest evaporation, per pound of oil, was 13.7 pounds, the generation rate being 3.7 pounds. This made the Babcock and Wilcox boiler about 3 per cent less economical than the horizontal boilers without retarders, and 11 per cent less economical than the boilers with retarders, even disregarding the superior capacity for forcing, as in the case of the horizontal boilers. These results were fully confirmed by observations covering a year's actual operation. I understand that later on a considerable improvement was made by using tile wall retarders in the Babcock and Wilcox setting.

PROF. WILLIAM KENT Mr. Bement's proposed setting shown on p. 246 is a long step in the direction of smokeless combustion and of maximum absorption of heat by the heating surface of the boiler. The regular feeding of coal by the automatic stoker and the long travel of the gases under a fire brick roof are two most important features tending to give smokeless combustion, and boilers set in this manner can no doubt be driven without smoke when the thickness of the fire and the force of the draft are so adjusted as to provide enough air at all times to burn the volatile gases.

2 One trouble with nearly all furnaces designed for the suppression of smoke is that they do not make any provision for increased air supply at times when the boiler is driven beyond its normal rate, or rather when the furnace is driven beyond the rate at which no smoke will escape from the chimney. If the boiler is running at its normal rate, the volatile gases being completely burned, and then an extra demand for steam makes it necessary to drive the furnace faster, coal must be fed at a faster rate and

the thickness of the bed of coal is thereby increased. This thickening of the bed increases the resistance to the passage of air through it, and if the draft is not correspondingly increased, or if there is no provision made for introducing air into the furnace above the coal, the air supply is diminished instead of being increased as it should be. I would therefore add to Mr. Bement's design some provision for an adjustable supply of air which could be admitted whenever the rate of feeding coal is increased to such a degree as to cause the production of smoke. Probably the best place to introduce this air is through the bridge wall and through openings which carry the currents of air in opposite directions to the currents of gas, so as thereby to make a thorough mixture. The air inlet should have an adjustable damper so that the additional air supply could be shut off when the boiler was being driven at a moderate rate.

3 I suggest that it would be well for Mr. Bement to make some experiments with this setting to determine the maximum rate at which the boiler could be driven with Illinois coals without smoke both with and without the admission of excess air above the grate. Chemical analyses of gases should also be made, and there should be an attempt to adjust the rate of feeding of coal to the air supply so that the CO_2 in the gases would approximate 14 per cent. It will probably be found difficult to get as high a percentage of CO_2 as this with rapid driving and smokelessness all at the same time, but a great deal of useful information could be gained from such tests, and we can especially learn from them something about the relation to each other of a high percentage of CO_2 (which means economy), rate of driving, and smokelessness.

4 In regard to what Mr. Bement calls balanced draft, he says that "it insures complete combustion with a smaller air supply than would be the case with induced draft alone." He does not give any reason for this conclusion and I am unable to find any reason for it. The examples he gives shows 5 per cent CO_2 in the furnace gases with natural draft and 7.32 with forced draft. Both of these figures are far below what they should be for good economy. Suppose that we have three boilers all exactly alike except that one is provided with forced draft, one with induced draft, and one with balanced draft. Let the total draft pressure necessary to burn the coal at a normal rate of driving be 0.3 inch, and at 50 per cent above the normal rate 0.6 inch; and suppose that the resistance to flow of gases through the fire is twice the resistance to flow through the boiler tubes. We then would have the following figures for the

draft pressure at the bottom of the chimney, in the furnace, and in the ash pit, for the six different cases considered:

	Normal Rate of Driving,			Rapid Driving,		
	Forced	Induced	Balanced	Forced	Induced	Balanced
Chimney	−.3	0	−.1	−.6	0	−.2
Furnace	−.2	+.1	0	−.4	+.2	0
Ash Pit	0	+.3	+.2	0	+.6	+.4

5 If in the case of rapid driving the coal bed is thickened so that the gases of combustion have the same analysis as when the boiler is driven at normal rate with thinner bed of coal, I can see no reason why the same percentage of CO_2 in the gases might not be obtained in all of the six cases. The mere fact that in two of these cases the draft pressure is zero in the furnace does not, it seems to me, have any necessary influence in changing the constitution of the gases or in enabling complete combustion to be made with a smaller air supply than would be the case with induced draft alone.

6 The fact that greatly different pressures of draft may give the same constitution of escaping gas is clearly shown in the report of a test of the Babcock and Wilcox boiler for the United States Steamship "Cincinnati," quoted in my book on Steam Boiler Economy, p. 397. In seven tests, the rate of driving of the boiler ranged from 5.18 up to 13.67 pounds of water per square foot of heating surface per hour. The average per cent of CO_2 in the gases varied only between 11.8 to 14.5. The percentage of CO_2 varied only from 0.2 to 1.5 and the percentage of oxygen only from 4.2 to 6.9. pounds of dry gas per pound of combustible varied only from 16 .8 to 20.6. The efficiency was remarkably high in all the tests, considering the very high rate of driving, ranging from 77.9 down to 64.5, the latter at the extreme rate of driving, of 13 67 pounds per square foot of heating surface per hour. It is not easy to see how this economy could have been improved by any system of balanced draft.

MR. W. L. ABBOTT In the territory which receives the greater part of its fuel from the coal fields of Illinois and Indiana a number of engineers are investigating the subject of boiler and furnace design, with a view to developing a type of apparatus better adapted to the long flame, high ash coals of that territory than the standard types of apparatus now on the market—something whose commercial efficiency will be above the 50 or 60 per cent, now obtainable, and which at the same time will relieve the owner from the

ever increasing persecutions of the smoke inspector. These investigations all point to three requirements essential for an ideal boiler plant using the grade of fuel above described, viz:

a A water tube boiler provided with an automatic stoker, which will gradually and continuously introduce fresh fuel at one end of the furnace and discharge the refuse from the other end.

b A tile roof above the furnace, extending well back of the fuel bed, which will compel the gases distilled from the fresh fuel to travel over the hot fire and back into a combustion chamber before permitting it to enter among the boiler tubes.

c An arrangement of baffles which will cause the gases to flow with velocity through every portion of the gas space of the boiler.

2 Every standard make of water tube boiler on the market possesses one or more of these qualifications, but none of them, so far as I am aware, possesses all of them. The advantages to be obtained by combining some of the best features of the different standard types of boilers into one design are manifest to those who have experimented with a boiler so modified, and yet when manufacturers are requested to furnish boilers so designed, each one objects to embodying in his own type some feature which he has not heretofore used, but which has proved to be one of the main advantages of boilers constructed by another maker. This conservatism, which exists in the selling departments rather than in the engineering departments, is being forced to listen to the demands for a special boiler design to meet the requirements of the users of cheaper grades of fuel, and I have no doubt that within a year or two they will all be glad to offer boilers designed substantially like the one which Mr. Bement describes.

PRODUCER GAS POWER PLANT

By J. R. Bibbins, Published in November Proceedings

Mr. W. D. Ennis There is in this paper what would seem to be a slight discrepancy. In Table 1, p. 198, the power building is stated to be 45 x 61 feet inside. This would make the area 2745 square feet and would give 6.1 square feet of area per kilowatt of capacity, exclusive (apparently) of the producer house. In the second column of this table, the power plant area is given as 7300 square feet, and that of the producer house as 7500 square feet. On this

basis, the total square feet per kilowatt of capacity would be 32.9. The new turbine power plant of the West Jersey & Seashore Railroad covers only 2.13 square feet of ground per kilowatt of capacity. The Summer-lane Station at Manchester, England, recently completed, uses 2.45 square feet per kilowatt, the plant containing both reciprocating and turbine engines. These are both much larger plants, however, than that which Mr. Bibbins describes.

2 Regarding the use of the term "loading factor," we need a name for this ratio, but would not "capacity factor" be better? We sometimes have occasion to consider also the relation of peak load to rated capacity. I would suggest, therefore:

Load factor = average load : peak load.
Capacity factor = average load : rated capacity.
Peak factor = peak load : rated capacity.
Load factor × peak factor = capacity factor.

A HIGH DUTY AIR COMPRESSOR

By O. P. Hood, Published in November Proceedings

Mr. Geo. H. Barrus This paper is noticeable in one respect, in that it presents the entire log of observations, as well as the horse power data of each indicator card. The logs and tables cover six pages of the Proceedings and one folder.

2 The summary of data and results is presented in accordance with the general form adopted in the Report of the Standardization Committee of the Society given on pp. 762–767 of Vol. XXIV of the Transactions, but it is noticeable that this summary omits all data under the subject of "Indicator Diagrams" given on p. 766 of the standard table. It also omits copies of the original diagrams called for on p. 769.

3 It is difficult to see wherein the complete log of observations and the areas of each indicator diagram are of interest to the Society at large. We can certainly take it for granted that these are bona-fide records and that the averages given in the summary represent the true data. On the other hand, the measurements of the diagrams called for by the standard form are important, and the quantities of steam accounted for by the indicator, which are omitted, furnish information which some engineers like to have in studying the results of an engine test. If the space taken up by the pages referred to were devoted in part at least to the interesting points covered by these omissions, it is certain that the paper would in no wise suffer.

4 The heat consumption given; viz, 10,157 B.t.u., equivalent to

1.016 pounds of "standard coal" per i.h.p. per hour, is based on the quantity of dry steam passing to the engine through the throttle valve. The weight of dry steam is found by deducting from the total water consumption the moisture shown by the calorimeter at the throttle valve, which is stated to be 5.74 per cent.

5 The percentage of moisture given is much greater than good practice warrants. This being the case, it would be interesting if the author would advance some reason for it. Was it due to some fault of the boilers, or, perchance, did the calorimeter give erroneous indications? In a test like this, where the results are claimed to establish a new record, the reliability of all the data should be carefully substantiated.

6 If the calorimeter gave an erroneous indication of the moisture, and the percentage were in reality no more than usual, then the heat consumed would be four to five per cent greater, and we should have the "standard coal" increased to about 1.06 pounds per i.h.p., per hour.

7 The special interest which this high engine performance has to engineers is the one relating to the advantages of the system, in point of economy, over the practice with which we are all familar. It may be doubted whether the record proves that the distinctive features of the engine, viz., the system of abstracting heat from the cylinders for warming the feed water, are so advantageous as at first sight appears. This statement is based upon the results of tests which have been conducted by myself on steam plants embodying the ordinary system, and one instance may be cited.

8 In a plant consisting of a 650 h. p. cross-compound engine, having cylinders with a ratio volume of 7 to 1, taking steam from vertical boilers at 150 pounds pressure fitted with an economizer, the actual coal consumption for all purposes was 1.18 pounds per i.h.p., per hour. With this result as a basis, it is easy to calculate what the consumption would have been with a pressure of 250 pounds, assuming that a third cylinder were introduced using steam at 250 pounds pressure, and exhausting into the h.p. cylinder of the engine at 150 pounds. It is a conservative estimate if we assume that such a cylinder would add one-third to the power developed, and do this without increasing the consumption of steam. In other words, it would reduce the coal consumption 25 per cent, and bring it down, in the instance cited, to about .9 per cent of a pound. per i.h.p. per hour. This is 11.5 per cent less than the weight of "standard coal" given in the paper, and 14 per cent less than the 1.16 pounds which may be the true performance of this engine, as surmised, and a still greater

percentage less than the actual amount of "standard coal" based on the heat units leaving the boiler, rather than on the heat units entering the engine, which, of course, is the basis of the real expenditure.

9 It would seem from the above calculation that a triple expansion engine can readily do as good work, and probably somewhat better work than the engine described in the paper, and no one can question the practical superiority of the triple engine in the matter of simplicity. The multitude of heaters pumps, etc., which form so necessary a part of the equipment of the quadruple engine described makes the engine decidedly lacking in that most desirable feature of steam machinery.

10 It is important to call attention to another matter. It would have been instructive if the records of the test had been supplemented by one made on the whole plant, embracing boilers and economizer, as well as the engine, so as to determine the actual coal consumption with this system. Such a test would have shown what benefit, if any, was derived from the economizer—an important apparatus with which the boilers were fitted. The probability is that the economizer was, in this case, of little use, for it could not have added much to the temperature of the feed water when the water was already heated before leaving the engine to 335 degrees. The question then arises, what useful object was attained by heating the feed water with steam derived from the engine, with its accompanying loss of power, when there was an economizer in the boilers which would have done the same heating with the waste gases? It is quite probable that, if a test had been made with two, or even three, of the heaters dropped off, little difference would have been found in the total coal consumption. It seems, therefore, that the system has no marked advantage when carried to the extreme limits indicated in this paper.

11 If we consider the steam engine as an apparatus for converting coal into power for commercial uses, it is certainly a wrong principle to take heat out of the steam in its passage through the various stages of the engine, and deprive the engine of that much power, when practically the same effect could be produced by utilizing the heat of the waste gases of the boiler without that loss of power.

MR. R. C. CARPENTER The engine described in this test is similar to that used at the Wildwood station which I tested in 1900 and which was described in a paper before the Society by Dr. Thurston. The test shows that the engine is a distinct improvement over the one at the Wildwood station in its efficiency of operation. The engine of the Wildwood station was, I believe, the

most economical on the basis of heat units supplied of any pumping engine which at that time had been tested. The test made by Professor Hood serves to indicate a distinct improvement in engine construction made by the Nordberg Mfg. Co. during the last six years. Both these engines were designed by Mr. Bruno Nordberg whom I consider one of the greatest engineers of this or any other age. His remarkable work has not been confined to the field of steam engines but has also covered with the same degree of success the air compressing and the mine hoisting machinery fields.

The paper covers very fully the construction of the engine and the details and results of the test. It gives, however, little or no information as to the construction and operation of the air compressor which the engine drove, and which I feel certain would have been of great interest to the Society if it had been described in detail.

THE ART OF CUTTING METALS

BY F. W. TAYLOR, PUBLISHED IN NOVEMBER PROCEEDINGS

MR. H. L. GANTT In our admiration of Mr. Taylor's paper as a piece of scientific investigation, we are apt to overlook two things which, to my mind, are of even more importance than the paper itself. They are:

a The object with which this investigation was undertaken;

b The far reaching results that have followed it.

2 Briefly, this object was to set proper tasks for machinists with specific instructions as to the best way and the shortest time in which to perform them.

3 The first result, and one soon obtained, was to find out that a proper task in machine work set by a competent man after an investigation was vastly greater than the task any man either would or could set for himself based on the knowledge he had, or could get. Similar investigations into other kinds of work indicated that this rule was far reaching, and during 26 years of work under all kinds of conditions, not one exception has yet been found.

4 In day work and in ordinary piece work, unless the matter has been studied very carefully, the workman practically sets his own task, which for day work is seldom more than one third of what he could have done, and often less than one fourth. His piece work task is seldom over, and generally much less than one half of what can be done.

5 Under the task system of management, each piece of work is carefully studied, and such a task is set as can be accomplished only by a good man fitted for the work. It is not expected that the ordinary man will succeed in doing it, at least not at first. The compensation is set at a figure much above that obtainable by the ordinary man, and almost always attracts the capable men.

The essentials of a task are:

a What shall be done;

b How it shall be done;

c How long it may take.

6 Such a system is so radically different from the ordinary one in which at least one and frequently all three of these conditions are left to the judgment of the workman, that a man familiar only with the ordinary system of management finds it very difficult to adjust his ideas to the new methods. When, however, he has become accustomed to the new methods, he very seldom has any desire to return to the old ones.

7 Mr. Taylor's investigation of the laws of cutting metals is simply an illustration of how each of the innumerable questions that arise each day must be answered, not by somebody's opinion, but by an investigation that will determine the facts. These investigations are expensive and no company can afford to undertake many at one time; but it has been the writer's experience that the value of facts is so much greater than that of opinions, that properly conducted investigations seldom fail to give a handsome return on the money invested in them. I limit myself, however, to properly conducted investigations, for a great deal of money is wasted by people who do not know how to investigate. Most investigations undertaken by people not specially trained lead to negative results and a loss of the money spent. The writer, however, has never yet seen a properly conducted investigation that did not more than pay for its cost. Fertile sources of failure in any investigation are too much "inherited" knowledge and too many theories on the subject.

8 In a proper investigation of any subject theories should be disregarded as much as possible, and facts sought for. After the main facts are known, a theory to explain them and to indicate a direction for further investigations may be very useful, but unless we are willing to give up such a theory that does not distinctly help us, it is apt to do more harm than good.

9 With regard to Mr. Taylor's paper, I think, and I believe Mr. Taylor will agree with me that, great as are the advantages to be gotten from a knowledge of the laws of cutting metals, to the engineer-

ing fraternity at large they are small compared to the value this investigation has as a part of the general subject of task management, the importance of which it is impossible to over-estimate.

10 So interested is Mr. Taylor in this subject and so convinced is he of its value in general, that he has for several years devoted most of his time without compensation to people who were trying to establish it, and is now always willing to help anybody interested in the subject.

THE FLOW OF FLUIDS IN A VENTURI TUBE

By Edgar Park Coleman, Published in November Proceedings

Mr. R. C. Carpenter The paper giving the results of the investigations made by Mr. Coleman in relation to the use of the Venturi tube for measuring gases and fluids generally, is valuable for giving the coefficient for the use of the Venturi tube and also of proving its accuracy for measurements of this kind.

2 Mr. Coleman makes no claim as being the inventor of the method of using the Venturi tube which he describes, the properties of which have long been known by engineers, and which is in extensive use for the measurement of liquids; but he does show its substantial accuracy for the measurement of both air and steam. He also presents a simple method of connecting up the tube so as to obtain the pressures required for computing the results.

3 The results which Mr. Coleman presents indicate that the Venturi tube can be used with confidence for the purpose of determining the weight of steam flowing through a given pipe. The use of the tube in the way described is such as to eliminate the costly operation incident to measurement of feed water supplied to a boiler or of the water discharged from a condenser, and I believe should receive the endorsement of engineers generally for such purposes, as soon as coefficients applying to various conditions can be accurately worked out.

4 The St. John steam meter, which is used quite extensively in New York City for the measurement of steam supplied by the steam heating company, employs a Venturi tube of much the same character as that described by Mr. Coleman. This meter is provided with a recording apparatus and arranged to produce a diagram with difference of pressure as ordinates and time as abscissæ. The integration of the diagram multiplied by a proper constant gives the steam discharged.

5 With the Herschel Venturi meter used for measuring water, an integrating device is a part of the meter.

IMPROVED TRANSMISSION DYNAMOMETER

By Prof. W. F. Durand, Published in November Proceedings

Mr. R. C. Carpenter The transmission dynamometer described by Professor Durand is, I think, well worthy a practical trial by those who desire an instrument for increasing power.

2 Some years ago while Professor Durand was at Sibley College he designed a dynamometer which worked on similar principles but in which the wheels supported by the testing lever were arranged on a shaft at right angles to the power shaft, and essentially as shown in the accompanying sketch.

3 I used the first dynamometer extensively in determining the efficiency and friction of bicycles while making an investigation of

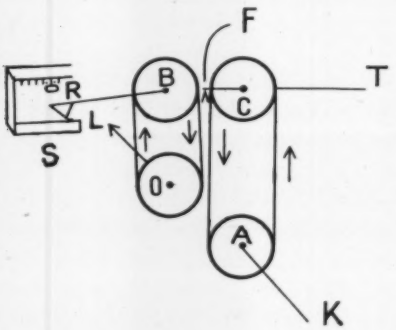

FIG. 1 SHOWING WHEELS SUPPORTED BY TESTING LEVER ARRANGED ON A SHAFT AT RIGHT ANGLES TO THE POWER SHAFT

the power losses in these machines. The dynamometer proved very satisfactory for that work and was, in fact, the only one that we found sufficiently sensitive and accurate. In that particular investigation it was necessary to measure with accuracy the results to about one half of one per cent of the total power transmittted; and this we found no difficulty in doing with the dynamometer in question.

4 The form shown in the paper is a distinct improvement over the older one for general purposes in the arrangement of the transmitting wheels in one plane and by the substitution of a sprocket chain for a round belt.

5 Investigation of the friction losses in sprocket chains leads me to believe that in the arrangement shown the friction is small

and principally confined to that at the bearings. This friction is quite certain to be practically constant under all conditions and of such a nature as to be determined by calibration, so that in practical use constants can be obtained which will entirely eliminate the effect of friction losses.

STEAM PLANT OF THE WHITE MOTOR CAR

By Prof. R. C. Carpenter, Published in November Proceedings

APPENDIX

The Author The reference to cut numbers, pages 274, 278 and 283, should be increased by 1.

TEST OF BURSTING STRENGTH OF TUBING USED IN THE MANUFACTURE OF THE WHITE STEAM GENERATOR

1 Two sizes of tubes were tested, one size being nominally $\frac{1}{2}$ inch internal diameter but with an actual internal diameter of .53 inches and external diameter of .72 inches. The other tubes tested had a nominal internal diameter of $\frac{3}{8}$ inches, an actual internal diameter of .372 inches and an external diameter of .53 inches. The tubes are named in the following table by their nominal internal diameter.

2 Before making the test the tubes were threaded and connected by means of short copper tube to a cylinder fitted with a plunger .804 inches in diameter (area = 0 .508 inches). The tubes and connections were filled with oil and the plunger forced into the cylinder by a testing machine, the pressure being noted.

3 The ends of the pipes were closed with fittings in each case; on half the tests a steel elbow and plug were used and for the remaining tests a brass union and brass plug were used. In all cases failure occurred in these fittings and not in the tubes. The internal pressure acted to expand the fittings so as to cause a leak in the joint. The following table shows results of the test.

$\frac{1}{2}$ inch Tubing, 2 ft. long closed with elbow and plug.

No.	Pressure actual	Pressure per sq. in.	Leakage occurred
1	9600	18900	At joint of elbow and tube
2	8550	16800	At joint of elbow and tube
3	7680	15100	At joint of elbow and tube
4	8600	16900	At joint of elbow and tube

½ inch Tubing, 2 ft. long, closed with brass union and plug.

No.	Pressure actual	per sq. in.	Leakage occurred
1	2950	5800	Between pipe and union
2	3700	7280	Between pipe and union
3	4000	7860	In union
4	3500	6880	In union

⅜ inch Tubing, 2 ft. long, closed with elbow and plug.

1	8250	16200	At joint of elbow and pipe
2	6400	12600	At joint of elbow and pipe
3	7670	15100	Around plug
4	9200	18100	At joint of elbow and pipe

⅜ inch Tubing, 2 ft. long, closed with brass union and plug.

1	5000	9840	In union
2	4740	9340	Around plug
3	5100	10000	Around plug
4	7040	13850	Around plug

PROFESSOR CARL C. THOMAS The curves which Professor Carpenter has presented as giving the values of the specific heat of superheated steam, have been plotted from the results of about seven hundred preliminary experiments made during the past year or more. The apparatus was designed by the present writer, upon the basis of about one hundred previously performed experiments, and the work that had already been done under Professor Carpenter's direction, and was most carefully and efficiently operated by Mr. C. E. Burgoon, the holder of a Fellowship in Sibley College, 1905–06.

2 We do not regard the results of these experiments as necessarily final. It seems probable that they are substantially correct, but their acceptance should be held subject to the results which are expected from the present continuation of the investigation.

3 The general principle of the apparatus is as follows: a given quantity of steam at constant pressure-and a given desired initial superheat, is passed through two exactly similar, electrically heated calorimeters, (marked 2 in all figures) where it is heated by electrical energy. The same quantity of steam is passed through each calorimeter. The two calorimeters are so constructed that there is an equal radiation loss from each, because the containing shell of each calorimeter is jacketed on the inside by steam of the same temperature, that is, by the entering steam before it is again heated. The steam passes, as indicated by the arrows, Fig. 1, through electrical heating coils so insulated from the entering steam

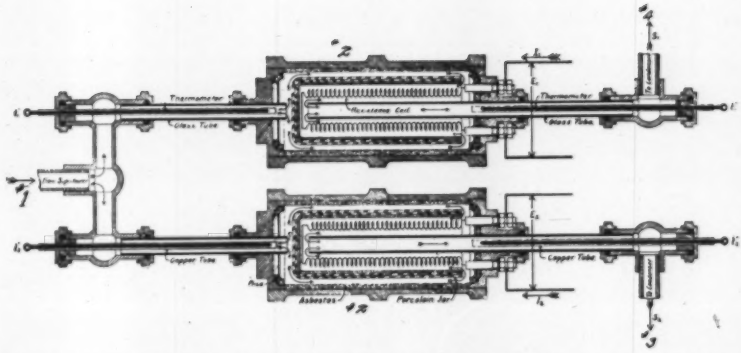

FIG. 1 SUPERHEATING CALORIMETERS FOR DETERMINING THE SPECIFIC HEAT OF SUPERHEATED STEAM

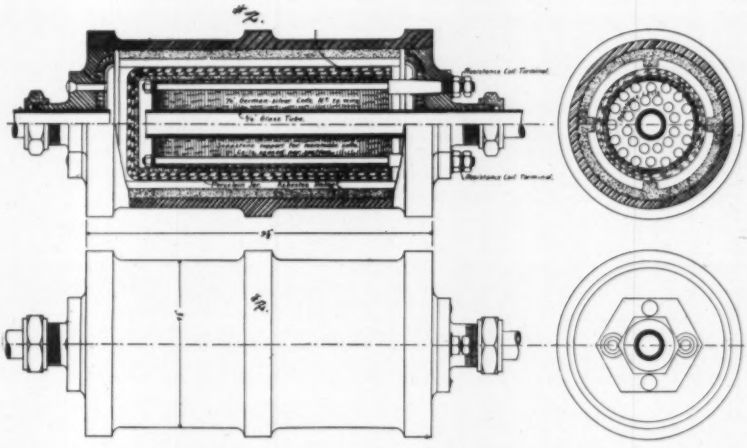

FIG. 2 SUPERHEATING CALORIMETER FOR DETERMINING THE SPECIFIC HEAT OF SUPERHEATED STEAM

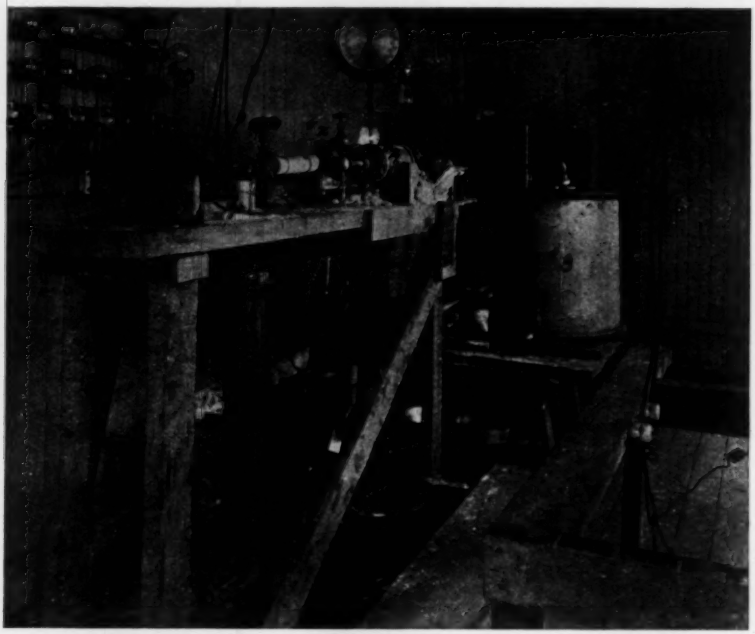

FIG. 3 SHOWING CONDENSER, ELECTRIC SUPERHEATER, TIME REGULATOR ETC.

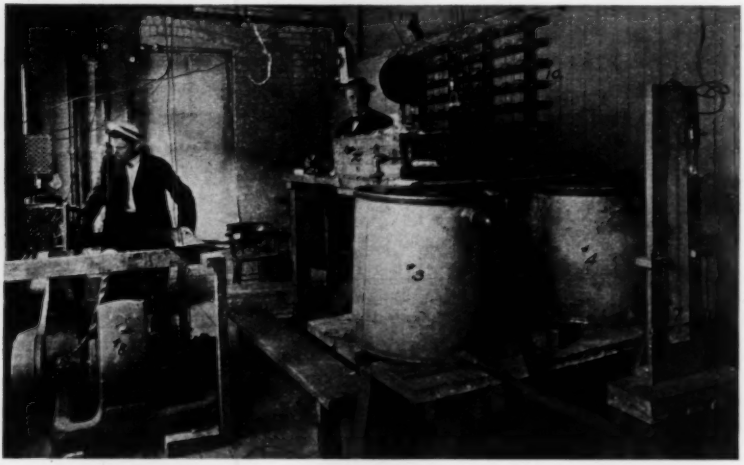

FIG 4 SHOWING CONDENSERS (3 AND 4), MEASURING TUBES (5 AND 6), ETC.

passage that the further superheating does not effect the temperature of the steam next the exterior walls of the calorimeter, and so the radiation remains the same from the two instruments.

4 In one calorimeter enough watts are introduced to heat the steam from the entering temperature of, for example, 250 to 270 degrees. In the other calorimeter, at the same time, the steam is being heated by sufficient watts to raise its temperature from 250 degrees (the same initial temperature) to perhaps 20 degrees higher than the final temperature in the other calorimeter, or 290 degrees.

5 There being the same quantity of steam going through each calorimeter, and the radiation loss from each being the same, the difference in watts required to effect the increases of temperature stated in the two calorimeters, represents the heat necessary to raise the given quantity of steam through, in this case, 20 degrees, or the difference between 270 and 290 degrees.

6 The steam passes from the two calorimeters through condensers, No. 3 and No. 4, Figs. 3 and 4, thence to measuring tubes Nos. 5 and 6, which have been accurately bored out, and are therefore of uniform diameter. These measuring tubes contain floats operating needle points No. 7. When the discharge valves from the calorimeters are so regulated that these two needle points pass up the scale marked No. 7 absolutely together, then there is the same quantity of steam passing through each calorimeter. When working below atmospheric pressure, closed measuring tubes are used, exhausted by an air pump, and carefully graduated gage glasses supplant the floats and needle points for showing the amount of condensed steam.

7 The steam enters and leaves the two calorimeters through glass tubes which thermally isolate the calorimeters and prevent conduction losses. The temperatures of incoming and outgoing steam are taken by means of thermo-couples placed in the glass tubes.

8 In building up the apparatus one after another of the causes of error in previous investigations have been attacked and eliminated by providing the following conditions:

a The production of a continuous supply of steam superheated to a given constant temperature and maintained at a given constant pressure. This has been accomplished by passing steam from a small water tube boiler through an electric superheater, No. 1, Fig. 3, before which was placed a separator and throttle valve. The steam pressure is kept uniform by a man at the throttle valve continuously observing a steam gage.

The steam passing through the electric superheater at constant pressure is raised in temperature by a constant and thoroughly controlled electrical input, until the steam, upon reaching the two calorimeters, (No. 2 in all figures) is at the given desired initial condition, ready to be heated further in the calorimeters for determining the specific heat. The steam enters and leaves the two calorimeters through the glass tubes described above and passes directly over or around the thermo-couples for measuring the temperatures.

b A uniform supply of electrical energy at a constant voltage, and means for varying the amount of electrical energy between narrow limits. This has been obtained by the use of a motor generator set marked 8, Fig. 4 equipped with a Tirrel regulator marked 9, Fig. 4. The resistances used for controlling the amount of current, consist largely of incandesent lamps marked No. 10, Figs. 3 and 4. These have been used because they are not much affected by temperature changes in the room, currents of air, etc. The input of electrical energy is measured upon a single milli-volt-meter so arranged as to read both volts and amperes. This is done to avoid the errors in reading two separate instruments.

c Means for absolutely measuring the temperature of the steam entering and leaving the calorimeters. After an extended experience with the best mercurial thermometers obtainable in this country and abroad, we have found that the lack of constancy of the mercurial thermometer renders it totally unfit for this class of work. We are therefore measuring temperatures by thermo-junctions which are readily inserted in a desired position and which we can calibrate with accuracy. We have tried platinum resistance thermometers but displaced them in favor of the thermo-couples.

d Means for eliminating the errors introduced by radiation of heat from the apparatus. This has been done as above described by arranging for equal radiation losses from the two instruments. To make sure that the radiation losses are the same from the two calorimeters special radiation runs are made by passing superheated steam through the calorimeters and intro-

ducing just enough electrical energy to equalize the entering and exit temperatures.

e Means for thermally isolating the apparatus and thus preventing loss of heat by conduction through pipe connections and supports. The pipe connections are the glass tubes described, and the supports are wooden blocks covered with Portland cement upon which the calorimeters rest.

f Means for obtaining a continuous measure of the amount of steam passing through the calorimeters; intermittent weighing of the condensed steam is not satisfactory. The continuous measure has been obtained by using the uniform diameter tubes containing the floats actuating needle points, or else fitted with small gage glasses in which the height of water can be accurately ascertained.

9 Observations made by the writer during the experiments, together with previous experience with steam calorimeters, led to the design of an electrically heated calorimeter for determining the quality of steam, and this calorimeter will now be described, as it is thought to be of especial interest in connection with steam-turbine practice.

CALORIMETER FOR DETERMINING THE QUALITY OF STEAM

10 Fig. 5 shows the exterior and the general interior arrangement of a steam calorimeter with which the quality of any steam passing through the calorimeter can be determined with accuracy in a very simple manner. The instrument is especially designed for determining the quality of steam at different points along steam turbines, and it can be used with steam of any degree of wetness and of any pressure above that in the condenser. The sampling tube leading to the calorimeter may be extended into any steam passage from one part of the turbine to another to varying depths, and the average quality may thus be investigated. From this information, combined with the results of ordinary tests, a curve may be drawn on a heat diagram, showing the distribution of the work done by the steam in the turbine, and indicating the efficiency of the various sets of blades or buckets. Such a curve may also be used to indicate the degree of initial superheat that should be used in the entering steam in order that the steam at any set of blades may be in a given desired condition as to heat contents.

11 The development of the instrument resulted from experi-

ments made by the writer in passing steam from an electrically heated calorimeter through a transparent glass tube. If the electrical energy supplied to the steam passing through the calorimeter was insufficient to dry the steam, the interior of the glass was clouded; also no rise of temperature was shown on a thermometer placed in the tube. By adding sufficient electrical energy to the steam, the interior of the tube cleared up at once, and the temperature began to rise at the same instant that the steam gave this evidence of being completely dry. It was therefore possible to measure directly the amount of heat required to dry the sample of steam, and from the known heat of vaporization of dry steam, and the known weight of steam passing through the calorimeter, the quality could be readily found,

12 In operation the calorimeter is attached to the turbine shell or other source of steam, by means of screw-thread A. The sampling tube, B, admits steam to the instrument, from which it passes to the condenser or to the atmosphere, through a pipe from the discharge valve, C. Having adjusted the discharge valve so it is passing a suitable quantity of steam, enough energy is turned in to heat the steam to dryness. The condition of dryness is indicated by an immediate rise of temperature as shown by the thermometer, if more than the requisite amount of electrical energy is supplied. For convenience let the watts necessary to dry the steam be called E_1. After noting this number of watts, the steam is further heated by additional watts E_2, till a temperature T degrees above saturation is obtained; say 20 degrees or 30 degrees superheat. This operation is for the purpose of ascertaining the weight of dry steam per hour, W_1, which was passing when the steam was just dry. The weight, W_2, passed through the valve after superheating will be less than the dry steam passed through, by some percentage represented by a constant, C, because of the increase in volume accompanying superheating. This has been determined by tests with the instruments. Also, the watts S, necessary to superheat a pound of steam to T degrees, as different pressures, have been determined. The latter, S, may be used instead of the specific heat of steam, and has the advantage of allowing automatically for radiation losses. The quality of the steam may be obtained either by use of the curve supplied with the calorimeter, or by the use of the specific heat for varying pressures. The use of the curve, however, eliminates entirely any uncertainty of the value of the value of the specific heat.

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13 Let W_1 = weight of dry steam passing per hour.

Then E_1 watts evaporates the moisture in W_1 pound per hour, and this energy is equivalent to $\frac{3.42\ E_1}{W_1}$ thermal units per pound of steam. Let this amount of heat be represented by H_x. Let W_2 = weight of superheated steam passing per hour = CW_1. Ther E_2 watts raises the temperature of CW_1 pounds of steam through T degrees, or $E_2 = CW_1S$ watts, where S represents the watts required to superheat one pound of steam per hour through T degrees, at the pressure in the calorimeter.

14 Then, $$W_1 = \frac{E_2}{CS}$$

and this value of W_1 may be substituted in the equation

$$H_x = \frac{3.42\ E_1}{W_1}$$

Thus, $$H_x = \frac{3.42\ E_1 \times CS}{E_2}$$

15 Since C and S are constants for any given pressure and degree of superheat, $3.42\ CS$ may be written as a constant, K, and values of this constant are given for varying pressures, by a curve supplied with the calorimeter.

The equation then becomes

$$H_x = K\ \frac{E_1}{E_2}$$

and if H_v represents the heat of vaporization of dry steam at the pressure indicated by the original temperature in the calorimeter, the quality of the steam passing through the calorimeter is

$$X = \frac{H_v - H_x}{H_v}$$

16 Summing up: to determine the quality of any steam passing through the instrument, introduce electrical energy till the thermometer just begins to show a rise of temperature. Note the watts, E_1, required. Then introduce further watts until a convenient degree of superheat has been reached, say 20 or 30 degrees. Note the watts, E_2, required.

17 From the curve select the value of K corresponding to the original temperature in the calorimeter and the degrees of superheat and find the thermal units from the equation,

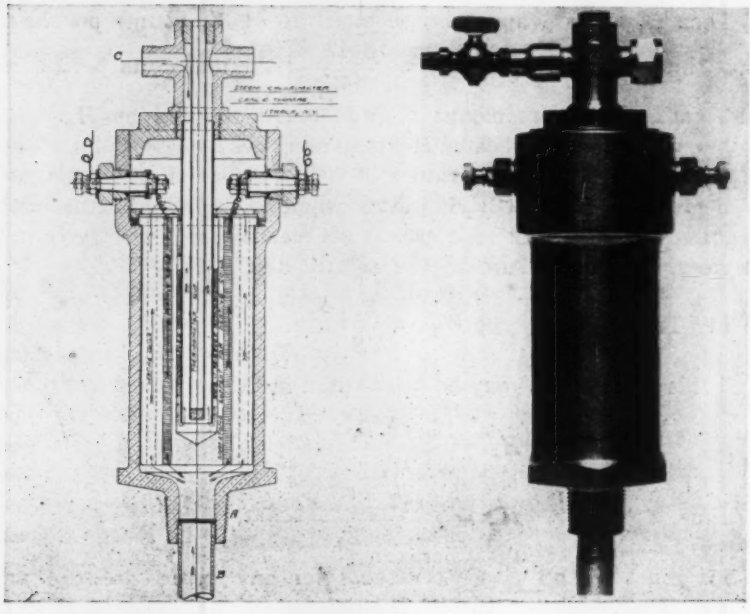

FIG. 5 DETAIL AND EXTERIOR OF STEAM CALORIMETER

$$H_x = K \frac{E_1}{E_2}$$

and the quality from the equation

$$x = \frac{H_v - H_x}{H_v}$$

18 For Example: Let the steam pressure be 100 pounds abs., at which the heat of vaporization is 884 thermal units, and let the value of K be found from the curve to be 54.2

If the watt-meter readings give $E_1 = 240.$ and $E_2 = 93.0$

$$\text{then,} \quad H_x = 54.2 \left(\frac{240}{93}\right) = 140.$$

$$\text{and} \quad x = \frac{884 - 140}{884} = .84, \text{ or } 84 \text{ per cent.}$$

19 Curves giving values of x for varying pressures and values of H_x are supplied with the calorimeter.

JUN 7 - 1929